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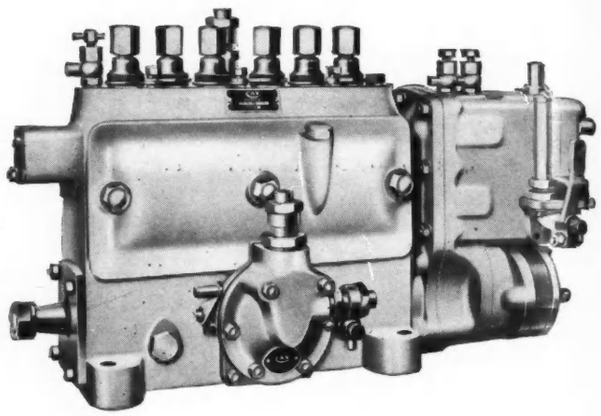

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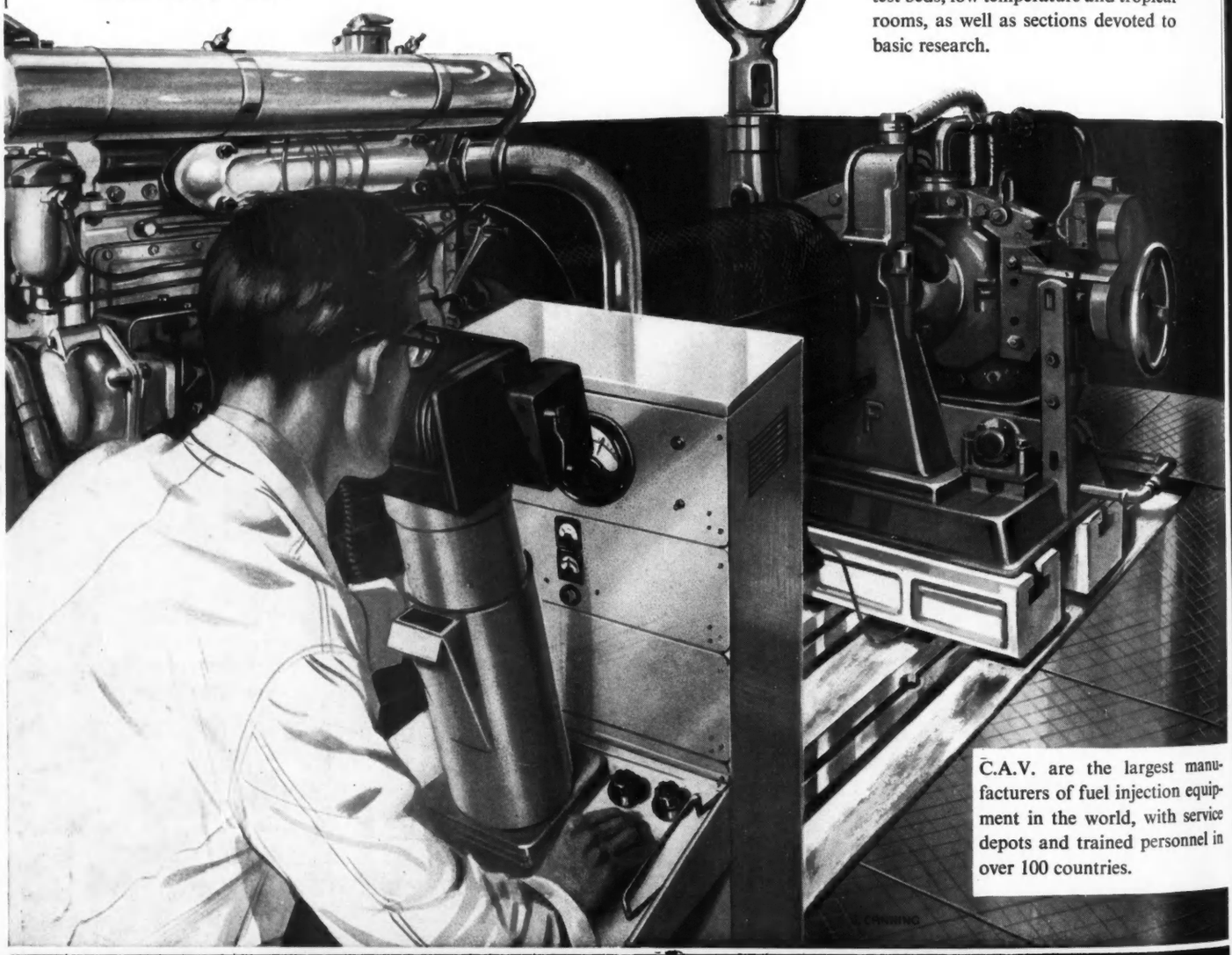

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POWER JETS' GAS-TURBINE PATENTS—V.*

COMPRESSORS.

PREVIOUS articles in this series have dealt with patents concerned mainly with the aeronautical application of gas turbines. In passing to patents concerned partly or wholly with other aspects of gas-turbine technology, it is proposed first to consider the major components of gas-turbine plant in the logical order, namely, compressor, combustion system and turbine. This section on compressors is divided into sub-sections dealing with centrifugal-flow and axial-flow machines, respectively; chronology dictates that the centrifugal-flow machine shall be first considered.

Centrifugal-Flow Compressors.—As in all but one of the previous sections, the first patent to be reviewed is one drawn to a Whittle invention; considerable use of the invention, both in this country and abroad, justifies the pride of place achieved through the possibly arbitrary method of seniority by age. One of the first tasks with which Whittle was confronted in his efforts to solve the gas-turbine problem was improvement of the efficiency of the centrifugal compressor, and patent No. 587,509 relates to one of the inventions which he made in the course of this work; the invention permits the attainment of relatively large volumetric capacity with, at the same time, relatively high efficiency due to the avoidance of high Mach numbers at entry to the impeller. As shown by the drawing reproduced as Fig. 1, guide blades 2A are provided to rotate with the radial vanes 2 of a centrifugal impeller and their leading edges increase in helical pitch progressively from root to tip; before reaching the rotating guide blades, the air entering the eye of the impeller (or rather the eyes of the bilateral impeller in the case illustrated) is engaged by fixed guide vanes 8, which impart to it whirl (usually called "pre-whirl") in the same rotational sense as that of the impeller and of such nature that, at all radii, the air is incident upon the rotating guide blades at little or no angle of attack. A series of annular cascade rings 7 is provided in each intake to form sub-divided channels in which the air is guided to impart the axial component necessary to bring it to the impeller. The illustration does not clearly show the form of the fixed guide vanes, which is arcuate in cross-section, the outer (or entering) edges being radial and the inner (or leaving) edges being inclined at an angle of about 45 deg. to the tangent to a circle about the impeller axis. The whirl component of velocity imparted to any particle of air by the time it reaches the rotating guide vanes is inversely proportional to its distance from the radius (that is to say, the conditions are those of a free vortex); this facilitates manufacture of the impeller in that the guide blades, their leading edges being radial at the roots, can be shaped by the bending of extensions of the main radial blades.

The next patent, No. 584,126, is concerned with the structural problem of rigidly supporting a compressor casing in relation to the associated bearings and other fixed parts of the compressor (and of an engine with which it may be associated) while at the same time offering as little obstruction as possible to the passage of air into the compressor. As shown by the drawing reproduced as Fig. 2, the solution lies in the use of a lattice structure 11A to attach the compressor casing to a rigid member (or members) 7A (and 8) so disposed axially as to allow an intake path of width not less than that provided at the eye of the impeller. The construction, known colloquially as the "birdcage," is particularly convenient in the case of a compressor with bilateral intake (as, in fact, illustrated by the drawing); Whittle, who was the inventor in this case also, used the construction in many of his designs and it will be recognised in many designs which can be considered as deriving from his in general respects.

The first engine to incorporate the "birdcage" was the Power Jets' W1A, which was installed in the Gloster E28/39 in replacement for the W1 engine with which the aircraft had earlier made the first gas turbine-engined flight in this country. The "birdcage," which provided a simple means of distinguishing the two engines upon casual inspection, is clearly visible in the photograph of W1A, which is reproduced as Fig. 3 and which also shows fixed pre-whirl guide vanes as described above with reference to Fig. 1.

Patent No. 587,514 relates to a compromise impeller design conceived to permit the attainment of a desirable aerodynamic feature without complicating manufacture in a case in which vanes, boss and disc portions are to be formed integrally. As will be seen from the drawing reproduced as Fig. 4, the faces of the impeller vanes, which are flat except for such fillets and tapers as may be required, are not substantially normal to the faces of the disc as is usual, but lie in planes which are inclined both to the axis and to the plane of rotation; the angle of inclination is that required at the root portions of the blades to achieve shockless entry at the eye of the impeller. If it is desirable, for example, due to the absence of controlled pre-whirl, for angle of

* Part IV appeared on page 583, *ante*.

Fig. 1.

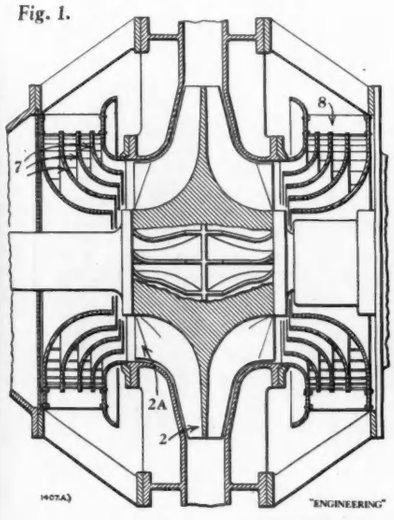


Fig. 2.

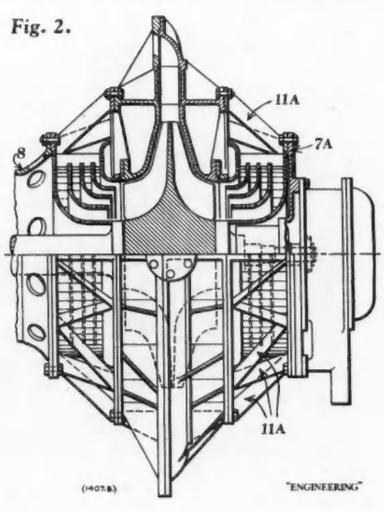
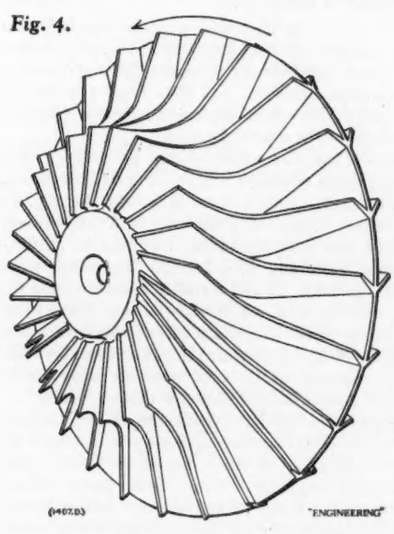


Fig. 4.



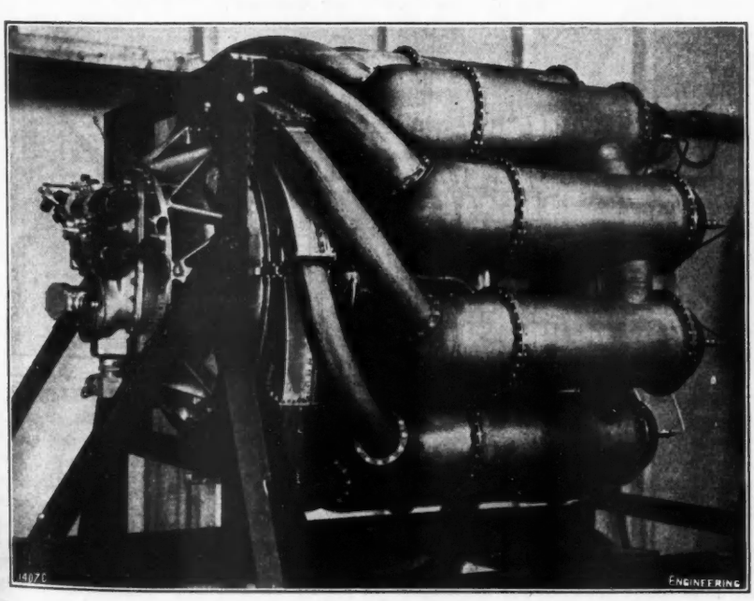


FIG. 3. W1A ENGINE.

incidence at entry to the vanes to vary with radial distance from the impeller axis, this may be conveniently catered for by bending at a late stage of manufacture; this operation is shown in progress in Fig. 5. The flat surfaces of the vanes facilitate machining with milling cutters and the design gives good stressing characteristics. When applied to a bilateral impeller, the design provides a "herring-bone" appearance and this is the name by which it is colloquially known.

Also concerned with vane form, but not with aerodynamic considerations, is patent No. 603,165. During development of some Power Jets' impellers, considerable trouble was experienced through vibration due to various causes. Several expedients were tried to meet these difficulties; that which forms the subject of the patent was intended mainly to combat the effects of a buffeting force concentrated in the vane region close to the rim of the disc, as may be caused by the presence of diffuser vanes or similar obstacles situated downstream of the impeller. The principle employed is that of decoupling into the disc instead of down the vanes, and this may be effected, as was done in the case of the impeller forming part of the rotor assembly shown in Fig. 6, by the use of vanes of which the tip portions are of wedge form in section; this gives them the properties of cantilevers with very high stiffness and frequency.

The theory is discussed at some length in the specification, and the inventor, Mr. R. G. Voysey, has given elsewhere (*Proceedings of the Institution of Mechanical Engineers*, vol. 153, 1945) a very full account of the work which was done on vibration problems at the time concerned.

Axial-Flow Compressors.—One of many Power Jets' patents relating to rotor drum construction is No. 610,314, which is here illustrated by Fig. 7. The drum comprises a number of axially-spaced wheels each carrying blades mounted in axially-directed slots and held together by compressive stress applied by a nut 5 threaded on a composite tie bar, the head 6 of which bears on the wheel at the opposite end of the drum. The compressive stress is taken wholly by abutment rings 9 situated between the peripheral portions of adjacent wheels and torque is transmitted through dogs 8 which are provided near the hub portions of the wheels and have the axial clearance necessary to ensure that they take none of the compressive stress. The abutment rings are formed with inner, stress-transmitting flange portions and outer flange portions which fair off the drum surface between adjacent blades and also serve to locate the latter within their slots. In addition to a multi-stage axial-flow portion, the rotor illustrated includes a high-pressure centrifugal-flow portion.

The next patent to be reviewed, No. 632,923, relates to somewhat similar subject matter. As shown by the drawing, Fig. 8, opposite, the drum resembles that of the earlier invention in that a number of wheels are held together by compressive stress which is taken solely at or near the periphery of the drum; in this case, however, the compressive stress is transmitted through the root portions of the blades themselves, which are nipped between peripheral flanges on the wheels. The flanges and the blade roots have complementary surfaces which engage to effect radial location of the blades.

The two rotor drum constructions above described may be used for turbines as well as for compressors and each permits the use of a light, robust structure comprising relatively small individual parts which can be easily inspected before assembly. Furthermore, each construction lends itself to uniform temperature distribution on account of the internal cavities in which air may be circulated; the construction illustrated by Fig. 8 has the further advantage that coolant may easily be led to cavities within the blades, as may be particularly desirable if the construction is employed in a turbine.

A third rotor construction, suitable for compressors and turbines, is illustrated by Fig. 9, opposite, and forms the subject of patent No. 611,405; it is intended to give the centrifugal stress characteristics of a solid disc combined with the whirling speed characteristics of a hollow drum. As will be seen,

POWER JETS' GAS-TURBINE PATENTS.

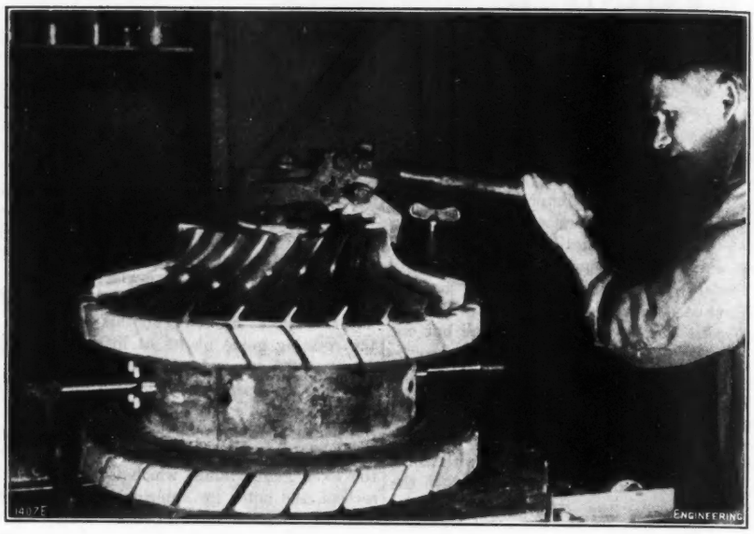


FIG. 5. BENDING TIPS OF IMPELLER VANES.

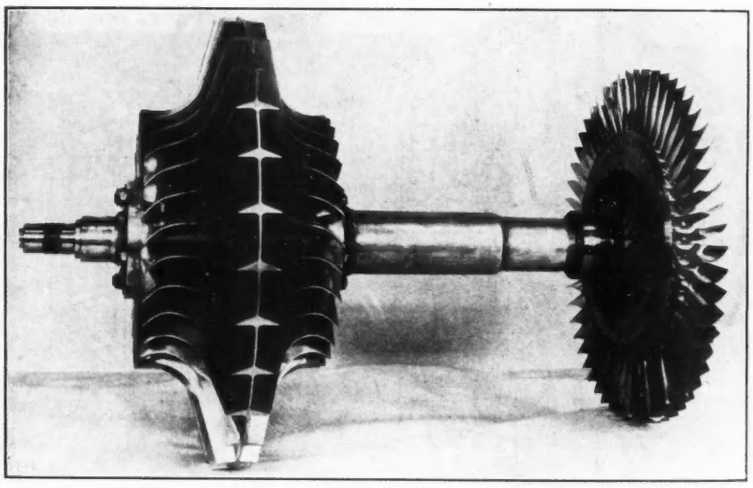
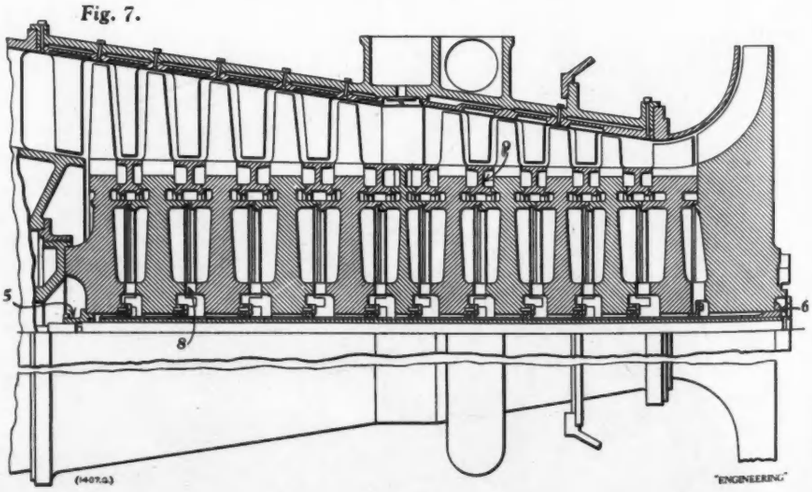


FIG. 6. COMPLETE ROTOR ASSEMBLY.

Fig. 7.



POWER JETS' GAS-TURBINE PATENTS.

Fig. 8.

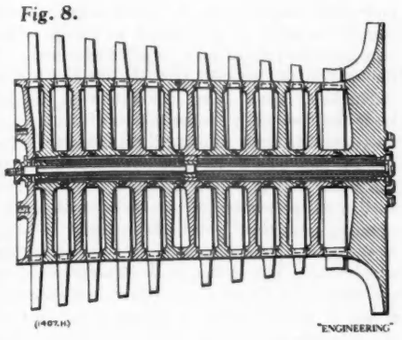


Fig. 10.

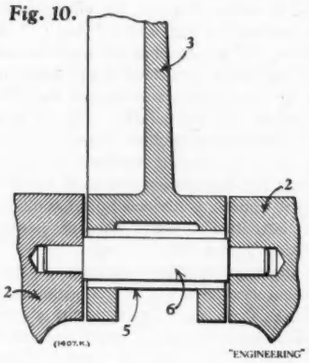


Fig. 12.

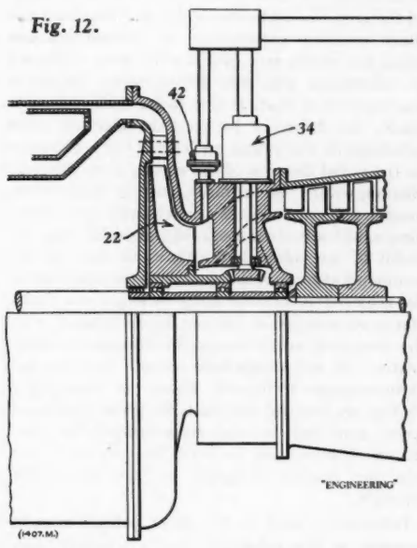


Fig. 9.

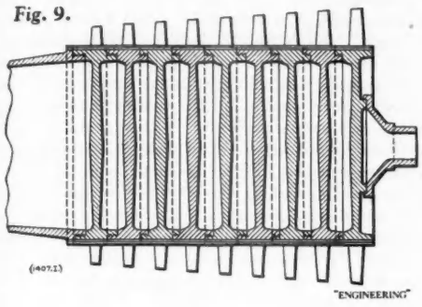


Fig. 11.

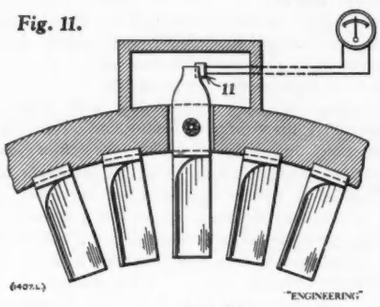


Fig. 15.

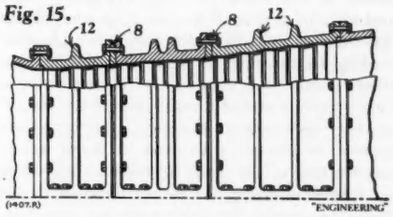


Fig. 13.

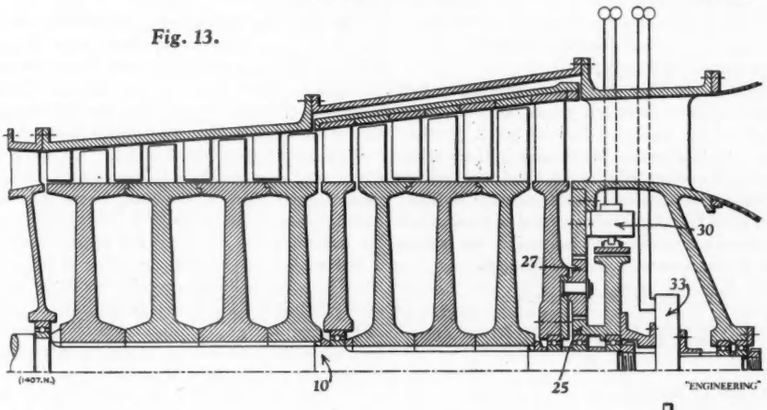
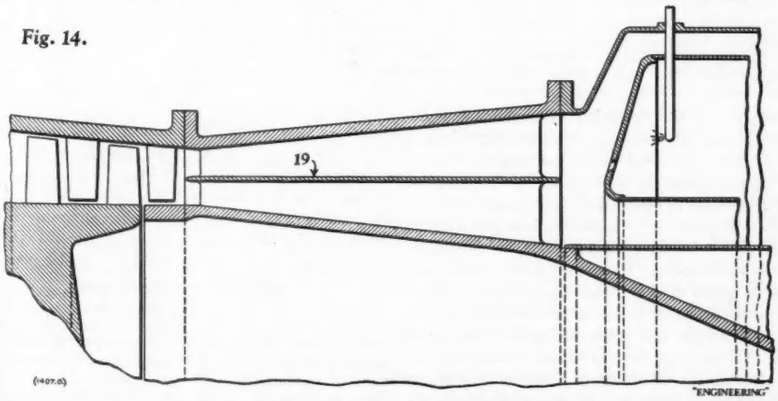


Fig. 14.



the rotor comprises a number of solid discs which are directly interconnected at their rims (by the screwing together of flanges in the example illustrated); blades are mounted in axially-directed grooves and spacing members (not clearly apparent from the drawing) are provided in the grooves between adjacent blades to span the joints between discs and lock them against relative rotation.

While it is common practice for designers of axial-flow compressors (and turbines) to seek to compensate the total forces on each blade (by so arranging the centre of gravity of the blade sections that centrifugal loads cancel out bending moments due to gas loads), the use of the orthodox types of rigid root-mounting limits the full effectiveness of such compensation to a particular design condition; thus, there will of necessity be an undesirable stress on the blade if the gas loading varies, say, due to change of air density, and blades will tend to be heavier than is strictly required under design conditions. An expedient suggested in the specification of patent No. 606,151 is to mount the blades so that they can tilt individually in the peripheral direction of the rotor to accommodate themselves to changes in the relative values of the centrifugal and fluid loads; an example of such an arrangement is illustrated in fragmentary axial section by Fig. 10, in which a blade 3 is shown mounted in a rotor drum 2 by means of an axially-extending pin 6 and needle rollers 5.

Sufficiently similar to be taken out of chronological order is patent No. 641,998. In this case, one or more stator blades are mounted so as to be able to tilt under the action of the fluid load and thus to indicate any change in such load. As illustrated by Fig. 11, one of the blades in a stator row is mounted for limited tilting movement about an axis parallel to that of the associated rotor. A detector device, such as a piezo-electric element, is provided at 11 to give remote indications of movements of the pivoted blade or to effect automatic control operations in accordance with such movements. It is suggested that the arrangement might be used in the interesting system of compressor control according to patent No. 612,414, which has already been reviewed in Part IV (Automatic Control of Gas Turbines).

The next patent, No. 587,518, differs from those already reviewed in that it is concerned with aerodynamic rather than structural features; like those previously reviewed, however, the invention to which it is drawn may be applied to turbines as well as to compressors. At the present time, practical application of the invention, which is considerable, is more to compressors than to turbines. Some years before the invention was made in 1943, advances in axial-flow compressor and turbine design had been achieved by adoption of blade profiles designed on the free-vortex principle —that is to say, profiles such that the absolute whirl velocity of the air leaving a rotor (or stator) stage varies along the blades of the stage in inverse proportion to the radial distance from the rotor axis. Many well-known advantages derive from free-vortex design; two major disadvantages may,

however, be cited. First, the blade profile has a very large twist, which results in considerable difficulty in the mass production of blades by many of the processes currently employed. Secondly, the Mach numbers experienced at different stations along the blades vary over a wide range. Blading in accordance with the patent under discussion has the feature that, at any radial station along a blade, the difference between the absolute whirl velocities at entry and on leaving vary inversely as the radial distance of the station from the axis. Blading within this definition may be designed for greater efficiency than is possible with free-vortex design, which latter is specifically excluded from the ambit of the patent but with which there is the common feature that the work done (or temperature rise achieved) is constant along the length of a blade. Many advantages of blading in accordance with the invention are discussed in the patent specification; it will suffice here to note that the two disadvantages attributed above to free-vortex blading are avoided and that, for given peripheral speed, axial velocity and stage temperature rise, the air deflection will be lower than would be the case for blading designed on the free-vortex principle.

Different in kind to the three patents already reviewed in this subsection are two patents concerned with the problem of starting large compressors or gas-turbine plant in which they are embodied. According to the first of these, No. 587,527, an auxiliary rotary compressor is interposed between the high-pressure end of a main compressor and an associated combustion system; the auxiliary compressor is driven by an external power source during starting of the plant to augment the effect of the main compressor, the supply of power to the auxiliary compressor being discontinued when the speed of the main compressor reaches the value necessary to render the plant self-driving. In the example shown in Fig. 12, page 611, the auxiliary compressor 22 is of the centrifugal-flow type and is driven for starting by an electric motor 34 through bevel gearing; when self-driving conditions have been reached, the pressure at the eye of the auxiliary compressor operates a switch 42 to cut off the supply to the electric motor. During normal running, the vanes of the centrifugal impeller serve as stationary guide vanes in the air-path between the main compressor and the combustion system.

According to the second patent, No. 587,529, the stator blading at the low-pressure end of a multi-stage axial compressor is caused, during the starting sequence, to rotate in the same direction as, but at a speed lower than, the compressor rotor; this not only reduces the power required for starting but also tends to improve the effective delivery of the compressor in the early stages due to the fact that the blading of the low-pressure stages will become unstalled at an early stage in the build-up of rotor speed. As shown by Fig. 13, page 611, the low-pressure stator structure may be alternately held stationary (for normal running) by a brake 30 or coupled (for starting) by a clutch 33 and epicyclic gearing 25, 27 to the rotor shaft 10; the brake and clutch are electrically controlled, preferably by automatic switchgear which becomes operative to cause the rotatable stator elements to be locked as soon as the rotor has attained the self-driving speed.

Patent No. 589,030 is concerned with the reduction of the length of a diffuser without, at the same time, reduction of its efficiency. It is well known that, if efficient diffusion is to be achieved, the taper or rate of change of cross-section of a simple diffuser passage must be below a limiting value at which the flow would break away from the passage walls; the satisfaction of this requirement may entail an inconveniently large diffuser length, particularly in the case of a compressor forming part of gas-turbine plant for installation in aircraft. The solution disclosed in the patent specification is the splitting of the diffuser into a number of parallel passages, in each of which the effective diffusion angle is between 4 deg. and 12 deg.: "effective diffusion angle" is defined as the angle between two opposite walls of a hypothetical equivalent diffuser passage of rectangular cross-section and of which the two other walls are parallel. Fig. 14, page 611, shows a radial cross-section through part of an annular diffuser situated between the axial-flow compressor and combustion system of a gas-turbine plant; the diffuser is divided by an annular partition 19 into two co-axial annular passages of appropriate effective diffusion angle.

Three examples of patents relating to rotor-drum construction were reviewed at the beginning of this subsection; from many relating to stator construction it should suffice to select one for review, namely patent No. 646,728. The construction according to this patent, illustrated by Fig. 15, page 116, provides a longitudinally-split casing which is capable of resisting distortion even under conditions of high pressure or temperature while being susceptible of easy dismantling and accurate reassembly, for example, before and after blade inspection or changing. Like the rotor constructions previously reviewed, this invention can be applied to both compressors and turbines. As shown in the drawing, successive part-annular casing members 12 are secured (e.g., bolted) to peripherally continuous one-piece rings 8, which are interposed between them. The rings are made of slightly tapering cross-section to facilitate removal of the casing members on dismantling and to prevent distribution of radial distorting loads from the casing members to the rings.

In most fields, there are many pending patent applications which have not yet reached the stage at which much publicity can be given to their contents. This is particularly the case in this section, for many inventions relating to axial compressors have originated in recent months from the National Gas Turbine Establishment; several of these relate to constructions aimed at cheapening the manufacture of compressors and their blading.

LITERATURE.

Heat Transfer Phenomena.

By Dr. R. C. L. Bosworth, Ph.D., D.Sc., F.Inst.P., Associated General Publications, Pty., Limited, Sydney, New South Wales, Australia; and Pergamon Press, Limited, 2, 3 and 5, Studio-place, Kinnerton-street, London, S.W.1. [Price 2 guineas.]

Because heat is the equivalent of mechanical work, and work, like electrical and chemical processes in general, is characterised by the movement of something from one place to another, the author suggests that the transfer of heat should be brought into line with such phenomena by regarding it as just another case of physical transportation. Hence he postulates the existence of "carriers," which are defined as mobile parts of a system, capable of absorbing either momentum, or the random molecular energy known as heat, at one place and giving it up elsewhere. He assumes that the heat carriers may be molecules, atoms, or electrons; molar assemblies, such as eddies or streams; or quanta of radiation.

With so wide a choice of mechanisms it is not easy to see that any simplification of the subject is to be attained by adopting his particular point of view. The first case to be considered is that of pure conduction in gases at moderate pressures, when no part is played by either radiation or convection. Under such conditions the molecules are assumed to act as carriers, so that the mode of heat transfer is identical with that of the ordinary kinetic theory. Radiant heat is the subject of the next chapter, and here again we have only one class of carrier, but the quanta which now do the carrying are not an integral part of the assembly, and have no fixed relationship with the number of molecules comprised in it. With regard to heat transfer in solids and liquids, if we except metals, in which the process may be attributed mainly to the motion of free electrons, the method of heat conduction (apart from convection in liquids), lends itself so badly to the notion of carriers that no attempt is made to bring them into the picture. Indeed, they seem to be ruled out altogether by the statement that it is now customary "to associate all thermal properties of such bodies with a set of standing acoustical waves the velocity of which depends on the elastic modulus of the medium concerned." This is said to be in accordance with the theories of Einstein and Debye, but the reader is left to imagine what is meant by the velocity of a standing wave. The remaining method of heat transfer, namely, by convection currents in liquids and gases, is a process in which microscopically observable groups of molecules could be considered to act as carriers. Nothing, however, seems to be gained by so doing, for in the chapters on forced and natural convection the treatment is based on the well-known principles of dimensional analysis. It may be mentioned that a table giving the physical dimensions of quantities associated with heat transfer contains several errors. There is also an error in the description of a diagram for facilitating the evaluation of logarithmic mean temperature differences, but the mistakes in question should be obvious to readers with a reasonable knowledge of the subject.

The last three chapters deal respectively with the transfer of heat when accompanied by a change of phase, as in evaporating and condensing processes; the analogy between the flow of heat and an electric current; and the bearing of the mathematical theory of similarity upon the problem of representing heat flow by some kind of model. The book, as a whole, is of a nature likely to appeal far more to the pure theorist than to the man whose interest in thermodynamics is confined to its practical uses. Its readability is spoilt by the apparent anxiety of the author to include the name of everybody who has ever published anything about the theory of heat transfer. For a little book, with fewer than 200 pages of text, to be interrupted by no less than 544 references in the reading matter to 404 different authors, in addition to bibliographies at the end of each chapter occupying an aggregate of over 7½ pages of small print, and a further five-page index of authors' names, is surely carrying documentation a little too far. Furthermore, even if the names, or initials, had always been correctly given, which they are not, very few of the references provide any useful information, and sometimes they are really banal. The reader is told, for example, who it was that stated, in 1947, that 85 per cent. magnesia was the most useful lagging for steam pipes, and also who announced the discovery, in 1938, that a trace of mineral oil was bad for heat transmission through a boiler plate.

Failure of Bridge at Ardrossan.—The road bridge over the railway at Parkhouse Road, Ardrossan, collapsed on April 26 when a tractor hauling a 35-ft. long trailer loaded with the bedplate and part of the crankshaft of a marine engine was passing over it. The load, weighing 85 tons, was on its way from the Greenock works of John G. Kincaid & Co., Ltd., to Glasgow. A hole about 20 ft. square has been left in the bridge, which spans the Glasgow-Largs railway line.

Silver Jubilee of K and L Steel Founders and Engineers, Ltd.—K and L Steel Founders and Engineers, Ltd., Letchworth, Hertfordshire, celebrated the 25th anniversary of their association with the "600" Group of companies by organising a gala on Saturday, May 2. This was attended by a majority of the employees of the company with their families, and by other guests, who were provided with a varied programme of entertainment.

TEMPERING AND THE PHYSICAL PROPERTIES OF STEEL.

Fig. 1.

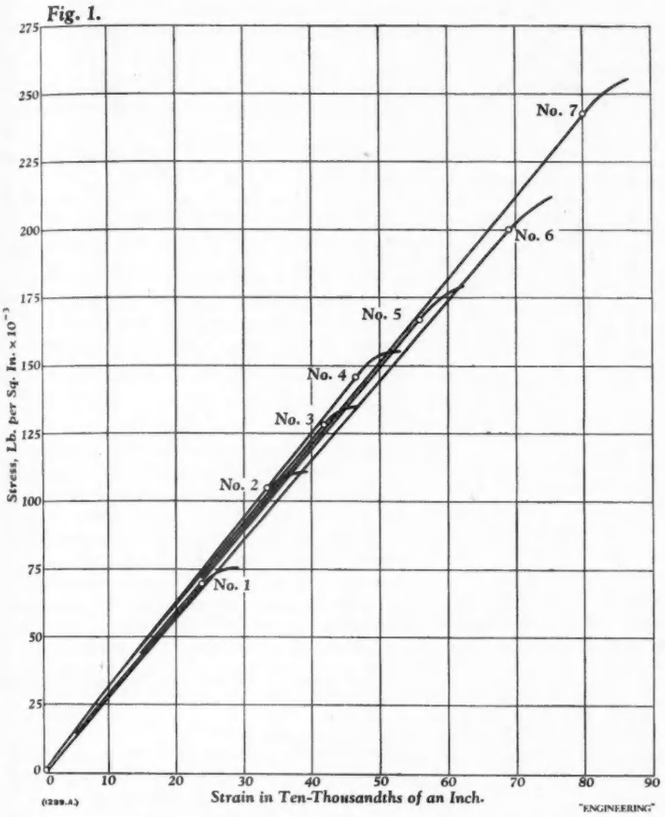
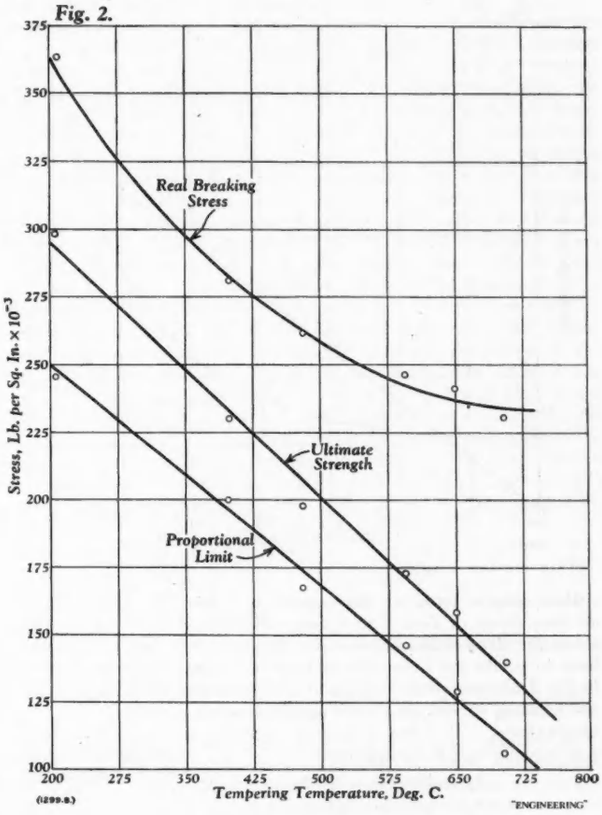


Fig. 2.



PHYSICAL PROPERTIES OF STEEL AS FUNCTIONS OF THE TEMPERING TEMPERATURE.

By A. A. PEEBLES.

IF the chemical composition of a steel is known, the effects upon its physical properties of the various heat-treating processes to which it may be subjected, and the temperatures at which such operations should be carried out, are familiar to all concerned with this branch of engineering. The purpose of this article is to show that, when an annealed steel is hardened and subsequently tempered, the principal physical properties may be expressed as mathematical functions of the tempering temperatures. It will also be shown that, by correlating the equations obtained, the major physical properties can be deduced, with reasonable accuracy, from any one of such properties which has been experimentally determined.

The mathematics involved are elementary, and will not be discussed in detail. To obtain satisfactory results the experimental work, particularly the heat treatments, must be carefully conducted with precision equipment, and must be fairly comprehensive. This work was carried out under the supervision of the writer in the materials testing laboratory of the Department of Aeronautical Engineering at the Provincial Institute of Technology and Art, Calgary, Alberta, Canada.

In this investigation, seven sets, each consisting of three test specimens, were cut from a bar of Ultimo 4 steel, made by the Atlas Steel Company, Limited. The following is the chemical composition of this steel, per cent.: carbon, 0·45; manganese, 0·75; phosphorus, 0·03 (max.); sulphur, 0·03 (max.); silicon, 0·21; chromium, 0·75; nickel, 1·75; and molybdenum, 0·40. Each set of test specimens consisted of a bar for testing in tension, one for the Izod notched-bar impact test, and a disc for the Brinell and Rockwell hardness tests.

All test specimens were annealed in a multi-unit electric furnace at a temperature of 840 deg. C., as specified by the manufacturers of the steel, a newly-calibrated Hoskins electric pyrometer and thermocouple being employed in reading this temperature and all other temperatures in the heat-treating operations.

Set No. 1 was left in the annealed condition. The other six sets were hardened by quenching in oil from a temperature of 840 deg. C., in accordance with the manufacturers' instructions. These six sets were then re-heated and tempered as follows: Set No. 2 at 705 deg. C.; No. 3 at 650 deg. C.; No. 4 at 595 deg. C.; No. 5 at 480 deg. C.; No. 6 at 400 deg. C.; and No. 7 at 205 deg. C. After tempering was completed, the scale from all specimens was removed. They were then polished with rouge on a buffing wheel. Finally, they were subjected to test in a Magna-flux crack detector to ascertain if any cracks had developed during quenching. No cracks were found. The testing was then proceeded with, the ultimate strength, proportional limit, real breaking stress,* Young's modulus, percentage elongation and reduction of area at fracture, Izod impact number and the Brinell hardness number being determined for each set. Brinell numbers were checked by the Rockwell test; in all cases, the two results were very close.

The tensile tests were carried out on a Sontag electro-hydraulic precision testing machine of 100,000 lb. capacity. The test bars had screwed ends and were 0·5 in. in diameter over the 2-in. gauge length. They were machined to the standard dimensions for such bars as specified by the Society of Automotive Engineers. The shackles for holding the bars had ball-and-socket seatings, ensuring an axial pull. Punch marks for attaching the strain gauge were made by a standard 2-in. spring-loaded punch, and strains were measured by a dial gauge, graduated in ten-thousandths of an inch. The testing machine allowed the load to be applied at a uniform rate throughout the whole range. The rate of load-application was kept constant, and very slow, in all tests, and the application was continuous, strain readings being taken at 500-lb. load intervals. The finished size of each test bar was carefully measured by micrometer after scale removal and polishing.

Impact tests were carried out on an Izod notched-bar testing machine, made by W. and T. Avery, Limited. The notches were cut with a special milling cutter and the bars were machined to gauges supplied by the manufacturers. The Brinell hardness numbers were determined by a Riehle hand-operated hydraulic unit. The impression was measured across two diameters at right angles to each other with a 20-magnification microscope in which a millimetre scale and an illuminating bulb were incorporated. The results obtained in these tests are given in the following Table.

In the harder test bars, such as Nos. 6 and 7, the yield points were not clearly defined. For this reason, the proportional limit, which can be accurately determined, was used in preference to the yield strength for all bars. Young's moduli were found to vary irregularly with tempering temperature, two of them (Nos. 2 and 4) being remarkably high. On account of the large number of readings taken below the proportional limit, and of the fact that all points on the stress-strain diagram were located on, or extremely close to, the mean line, there is little room for error in determining these values.

* To avoid misunderstanding due to possible differences of terminology between Canada and Great Britain, it should be explained that ultimate strength is here determined from the original cross-sectional area of the bar and the maximum load supported. Real breaking stress is calculated from the load at the instant of failure and the reduced area at the fracture point.

TEMPERING AND THE PHYSICAL PROPERTIES OF STEEL.

Fig. 3.

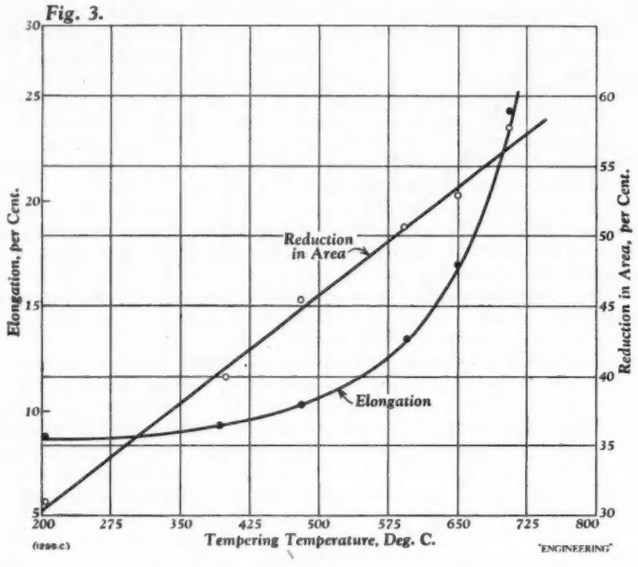
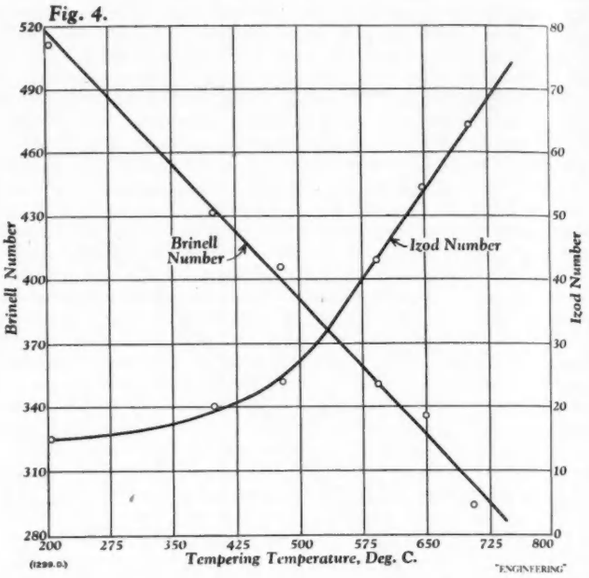


Fig. 4.



Mean graphs, based on the experimental data, are reproduced in Figs. 1 to 4, herewith. Fig. 1 shows the stress-strain diagrams for all seven test bars, to points just above the proportional limits. In Fig. 2, ultimate strengths, proportional limits and real breaking stresses are plotted against tempering temperatures. The first two give straight-line graphs conforming to the equations

$$f_u = 359{,}000 - 315\,T. \quad . \quad (1)$$

$$f_p = 307{,}000 - 279\,T. \quad . \quad (2)$$

The curve of real breaking stresses follows very closely the law

$$f_b = 2{,}770{,}000\,T^{-0.38}. \quad . \quad (3)$$

over the required range. In these equations f_u is the ultimate strength, f_p the proportional limit, and f_b the real breaking stress in lb. per square inch. In all equations, T is the tempering temperature in deg. C.

In Fig. 3, elongations and reductions in area at fracture, expressed as percentages of the original length and cross-sectional area, are plotted against tempering temperatures. The former gives a curve having for equation, over the required range,

$$e = 5{\cdot}075 \times 10^{-17}\,(T^{4.125}) + 8{\cdot}66. \quad (4)$$

The latter is a straight-line graph, the equation for which is

$$R = 20 + 0{\cdot}0517\,T. \quad . \quad (5)$$

where e is the percentage elongation and R the reduction in area at fracture.

Brinell hardness numbers are plotted against tempering temperatures in Fig. 4, giving another straight-line graph. This does not quite conform to common experience. Normally, for a fully-hardened plain carbon steel of equivalent carbon content to that used in this investigation, the Brinell No. – temperature graph is a contraflected curve, a mean straight line through which would give only approximate results. An examination of the point-locations experimentally determined, and as checked by the Rockwell test, will show, however, that a straight-line graph is clearly indicated. The equation of this line, as drawn, is

$$N_b = 606 - 0{\cdot}428\,T. \quad . \quad (6)$$

where N_b is the Brinell number. Also included in Fig. 4 is a graph of the Izod impact numbers, plotted against drawing temperatures. The equation

$$N_i = (3{\cdot}79 \times 10^{-13})\,T^5 + 15. \quad (7a)$$

fits this curve up to temperatures of about 550 deg. C., N_i being the Izod number. For higher temperatures, this equation gives results above those experimentally determined, the error becoming progressively greater as the tempering temperature increases. The location of the points for temperatures above 550 deg. C. is such that a straight line can be drawn through them without material error. Such a line has for equation

$$N_i = 0{\cdot}193\,T - 71. \quad . \quad (7b)$$

By correlating equations (1) to (7*b*), formulae may be derived expressing, for this particular steel, the major physical properties in terms of any one ascertained property. The results of some of the more useful of such correlations are developed below.

Combining any two straight-line equations will result in a simultaneous equation of three variables. One of these will be the tempering temperature, T. By eliminating, in each case, the term containing this variable, one of the remaining variables can be expressed in terms of the other. Doing this will yield the following results, all stresses being in lb. per square inch.

Ultimate strength and proportional limit, equations (1) and (2).

$$f_u = 1{\cdot}13\,f_p + 12{,}000. \quad . \quad (8)$$

Ultimate strength and Brinell number, equations (1) and (6).

$$f_u = 737\,N_b - 85{,}000. \quad . \quad (9)$$

Ultimate strength and reduction in area, equations (1) and (5).

$$f_u = 480{,}000 - 6{,}100\,R. \quad . \quad (10)$$

Proportional limit and Brinell number, equations (2) and (6).

$$f_p = 652\,N_b - 89{,}000. \quad . \quad (11)$$

Proportional limit and reduction in area, equations (2) and (5).

$$f_p = 416{,}000 - 5{,}410\,R. \quad . \quad (12)$$

Brinell number and reduction in area, equations (5) and (6).

$$N_b = 771 - 8{\cdot}26\,R. \quad . \quad (13)$$

The equations of curves may be correlated with each other, or with straight-line equations, by simple algebraic transpositions and substitutions.

For example, combining equations (3) and (7*a*) will give:

$$f_b = 2{,}770{,}000\,T^{-0.38} \quad . \quad . \quad (a)$$

$$N_i = (3{\cdot}79 \times 10^{-13})\,T^5 + 15 \quad (b)$$

Transposing equation (*a*)

$$T^{-0.38} = \frac{f_b}{2{,}770{,}000}. \quad \therefore T = \left(\frac{2{,}770{,}000}{f_b}\right)^{2.63}.$$

Substituting this value in equation (*b*)

$$N_i = (3{\cdot}79 \times 10^{-13}) \left[\left(\frac{2{,}770{,}000}{f_b}\right)^{2.63}\right]^5 + 15$$

$$= (3{\cdot}79 \times 10^{-13}) \left[\frac{2{,}770{,}000}{f_b}\right]^{13.15} + 15$$

$$= (3{\cdot}79 \times 10^{-13})\,[2{,}770{,}000\,f_b^{-1}]^{13.15} + 15$$

Some of the more useful of such derived equations are stated below, all stresses being in lb. per square inch.

Ultimate Strength and Izod Number, equations (1) and (7*a*).

$$f_u = 3{\cdot}17^{-1}\,[1{,}138{,}000 - 10^{5.6}\,(0{\cdot}264N_i - 3{\cdot}96)^{0.2}]. \quad (14)$$

If T is above 550 deg. C., from equations (1) and (7*b*)

$$f_u = 243{,}000 - 1{,}630\,N_i. \quad . \quad (15)$$

RESULTS OF TESTS.

Set No.	1	2	3	4	5	6	7
Tempered at deg. C.	As Annealed	705	650	595	480	400	205
Ultimate strength, lb. per sq. in.	140,000	140,000	158,000	172,800	198,000	230,000	299,000
Proportional limit, lb. per sq. in.	71,000	107,000	128,000	147,000	167,500	200,000	245,000
Real breaking stress, lb. per sq. in.	188,000	231,000	242,000	247,000	262,000	282,000	364,000
Young's Modulus, lb. per sq. in.	$29{\cdot}6 \times 10^6$	$31{\cdot}4 \times 10^6$	$30{\cdot}5 \times 10^6$	$31{\cdot}4 \times 10^6$	30×10^6	$29{\cdot}1 \times 10^6$	$29{\cdot}8 \times 10^6$
Elongation at fracture, per cent.	15	24	17	13·5	10·3	9·3	8·9
Reduction of area at fracture, per cent.	41·5	58	53	50·5	45·5	40	31
Izod number	14	64	54	43	24	20	15
Brinell number	286	293	335	351	406	432	512

Proportional Limit and Izod Number, equations (2) and (7*a*).

$$f_p = 3 \cdot 59^{-1} [1{,}100{,}000 - 10^{5 \cdot 6} \cdot (0 \cdot 264 N_i - 3 \cdot 96)^{0 \cdot 2})]. \quad (16)$$

For values of T above 550 deg. C., from equations (2) and (7*b*),

$$f_p = 205{,}000 - 1{,}445\, N_i. \quad . \quad (17)$$

Elongation and Izod Numbers, equations (4) and (7*a*).

$$e = 5 \cdot 075 \times 10^{-1 \cdot 1} (0 \cdot 264\, N_i - 3 \cdot 96)^{1 \cdot 125} + 8 \cdot 66. \quad (18)$$

From which the further equation

$$N_i = 8\,(e - 9)^{0 \cdot 817} + 15. \quad . \quad (19)$$

can be deduced. If T is greater than 550 deg. C., then from equations (4) and (7*b*),

$$e = 5 \cdot 075 \times 10^{-17} (5 \cdot 2\, N_i + 368)^{6 \cdot 125} + 8 \cdot 66. \quad (20)$$

Izod and Brinell Numbers, equations (6) and (7*a*).

$$N_i = 3 \cdot 79 \times 10^{-13} (1{,}414 - 2 \cdot 335\, N_b)^5 + 15. \quad (21)$$

Or, from equations (6) and (7*b*), where T is above 550 deg. C.,

$$N_i = 202 - 0 \cdot 45\, N_b. \quad . \quad . \quad (22)$$

Supplementary tests were made on a nickel steel of the same carbon content, but with the manganese reduced from 0·75 per cent. to 0·6 per cent., the nickel increased from 1·75 per cent. to 3·5 per cent., and the silicon, chromium and molybdenum omitted. As might be expected, these differences in chemical composition resulted in a steel of lower hardenability, giving increased ductility and decreased hardness and strength at all tempering temperatures.

Four sets of test specimens were prepared and tested in exactly the same manner as that already described. They were all hardened in oil and then tempered at 204 deg. C., 370 deg. C., 540 deg. C., and 704 deg. C. The four points thus obtained were sufficient to permit graphs of reasonable accuracy to be drawn. This was done, and the equations of the resulting lines and curves were calculated. In every case, these were found to be of the same type as those obtained for the Ultimo 4 steel, with the possible exception of the Brinell No.-temperature graph. In this case, the location of the points experimentally determined suggested a more typical contraflected curve for this function. To conform to the procedure followed in the first tests, however, a mean straight line was drawn among the points. The maximum deviation of this line from the curve drawn through the points was found to be 3½ per cent. at the two extremities of the graphs. This is not too serious an error, perhaps, in an analysis which professes to give reasonably accurate, rather than precise, results.

In the equations obtained from this supplementary investigation, all the constants differed materially from those obtained in the first experiments. The value of all such constants will depend upon the chemical composition of the steel and, in any given steel, upon the cooling rates employed in the hardening process. Any generalisation based on these two series of tests is unjustifiable; further research is called for. Circumstances, however, prohibit the writer from proceeding with this work at the present time.

The confirmatory results obtained are, at least, suggestive. They propound the probability that, for all steels and for normal cooling rates on quenching, the principal physical properties may be expressed as mathematical functions of the tempering temperature. In view of the fact that the changes which occur in the constituents and structure of the steel on re-heating after hardening are gradual rather than sudden, this presumption would appear to be logically sound.

It is the practice of United States steel manufacturers to supply customers with booklets dealing with the various specifications of heat-treatable steels which they produce. These give details of the recommended heat treatments and the temperatures at which they should be carried out, together with information as to the physical properties which will result. This information is set out in tabular form, but the physical properties resulting from tempering are usually given only for three or four temperatures, leaving intermediate points to be determined as accurately as possible by interpolation. Also, the physical properties tabulated are usually confined to the ultimate strength, yield point, percentage elongation, Brinell or Rockwell number and, sometimes, reduction of area at fracture.

If, in place of such tabulated data, manufacturers evolved for each of their products equations such as those herein developed, the necessary information would be conveyed to the purchaser in more compact and comprehensive form. Thus, from equations such as Nos. 1 and 4, he could determine the tempering temperature to give the combination of strength and ductility best suited to his purpose, and from the other equations any physical properties of interest to him could be deduced with reasonable accuracy.

Many engineering firms, especially those operating on a comparatively small scale, do not have material-testing equipment adequate for carrying out tests such as those described above. The installation of Brinell-hardness and Izod impact-testing units involves small capital outlay, occupies little space, and the tests are easily and quickly performed. These two items of equipment, in conjunction with the equations relative to the steel being used, are sufficient to indicate whether the heat-treating processes have been carried out satisfactorily or not, and whether the steel is of the specified quality. Thus, if, on test, the Brinell and Izod numbers check with those calculated from the relative equations (Nos. (6) and (7*a*) or (7*b*)), it may be safely assumed that the quality of the steel is satisfactory and that the heat treatments have been properly conducted. Any other physical properties, the values of which it is deemed desirable to know, can then be calculated from these numbers with reasonable confidence.

ELECTRIC-TRACTION BRAKING—IV.*

By T. F. WALL, D.Sc., M.I.E.E.

ELECTRIC BRAKING FOR TRAM-CARS.

For street tramways electric braking is practically universal, and for this purpose the normal switch-gear, controller, motor and resistances can be used without any very costly additional appliances; trailer-cars can be braked by solenoid magnets or other types of brakes. In this way, completely adequate control of the cars can be obtained. For main-line railways, however, the conditions are different. Apart from the much greater horse-power involved, the characteristic feature of railways is the use of electric locomotives, and since the carriages may be used for other services, they must be provided with compressed-air brakes; even for motor coaches, air brakes are always installed for safety. Nevertheless, electric braking forms a valuable supplement to the air brakes, and when regenerative control is provided, as, for example, on routes which have steep gradients, valuable economic results can be obtained.

In view of the continually increasing speeds being adopted for railway operation, electric braking is becoming of much greater importance and new developments are being introduced which give a remarkably flexible control of the torque-speed characteristics during the braking periods.

Fig. 7, page 616, shows, in skeleton outline, the diagram of connections for a tram-car motor, and the characteristic features of this diagram need no explanation. Fig. 8, page 616, shows the re-arrangement of the circuit for braking. As has been pointed out, when mechanical braking is used exclusively, the wear on the friction surfaces is very great and the cost of maintenance is correspondingly high. Moreover, the dust developed may seriously impair the insulation. Electric tramcars are practically always operated by direct-current series motors, and for braking purposes the motors are disconnected from the supply lines and the armature leads are interchanged.* The series circuit of the motor is then closed through a resistance which can be varied in steps so as to maintain the required braking torque as the speed falls. The same controller and resistances are used for braking as for speed regulation, and Fig. 7 shows the connections when the motor is being started; Fig. 8 shows them when the machine is being used to generate braking current.

The simplest and most generally useful method for determining the necessary resistances of the various steps for the braking operation is the graphical method shown in Fig. 9, page 616. When the circuit of the series-wound direct-current motor is disconnected from the supply lines and is connected across a resistance R, as shown in Fig. 8, the induced e.m.f. E_a will produce a braking current of I amperes, such that, $E_a = I R$. The magnitude of the induced e.m.f. will then be

$$E_a = \frac{\Phi Z p n}{a \times 10^8}, \quad . \quad . \quad . \quad (29)$$

where the factors a, Z and p are constants of the machine.

This equation may be re-written in the equivalent form

$$\Phi k = \frac{E_a}{N}, \quad . \quad . \quad . \quad (30)$$

and it is also to be noted that the quantity Φk is known when the current I is known. Consequently, Table I, page 616, can be derived as will be seen from the numerical example given below.

The symbols used in expression (29) are defined as follows:

Φ, in c.g.s. lines, is the flux per pole,
Z is the total number of active conductors,
p is the number of pairs of poles,
a is the number of pairs of armature paths,
n is the armature revolutions per second,
N is the armature revolutions per minute, and
k is a constant of the motor.

Numerical Example.—A direct-current series-wound motor is rated at 35 h.p., and the resistance of the field and armature winding is $R_a = 0 \cdot 45$ ohm. The speed-current characteristic when running under normal conditions, with a supply pressure of 500 volts, is given by C D in the graph on the right of Fig. 9.

If now, for example, the speed is N = 500 r.p.m., reference to Fig. 9 shows that the corresponding value of the current will be 60 amperes under normal running conditions, indicated by the point s on the speed-current characteristic of the motor.

From these numerical data it is seen that the induced back e.m.f. corresponding to the point s is

$$E_a = 500 - 60 \times 0 \cdot 45 = 473 \text{ volts.}$$

By repeating this procedure for several points on the speed-current characteristic, the data given in Table I† have been derived.

For the practical application of this method of tram-car braking, the circuit connections are shown in Fig. 8. The motor is disconnected from the supply lines and connected across a resistance of such magnitude that, for the initial braking speed, the current will not exceed a given specified value,

* Part III appeared on page 419, *ante*; the concluding Part V will appear shortly.

* When the motor is running as a generator for braking, the current will flow in the opposite direction to that which obtains when it is running as a motor. By interchanging the leads, the remanent magnetism of the poles enables the machine to self-excite.

† It should be noted that Table I refers to the conditions when the machine is running normally as a motor, the resistance of the circuit then being $R_a = 0 \cdot 45$ ohm.

$I_{max.}$ amperes. When the current has fallen to a given specified minimum value $I_{min.}$, a section of the braking resistance is cut out, so that the current again reaches the specified maximum value, and so on, thus giving the zig-zag diagram of Fig. 9.

The simplest way of determining the required values of the resistance sections is to use a graphical method, and this method will be explained with reference to Fig. 9. For this purpose, it will be assumed that the braking operation begins when the speed of the motor is 900 r.p.m., and it will also be assumed that the maximum permissible current is $I_{max.} = 70$ amperes. When the current has fallen to the value $I_{min.} = 40$ amperes, a section of the resistance R is cut out, so that the current again reaches the given maximum value, and so on.

Reference to Table I shows that when the current reaches its maximum value and the speed is 700

Fig. 7.

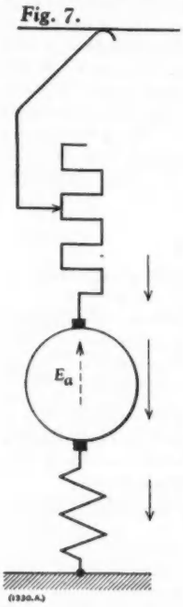
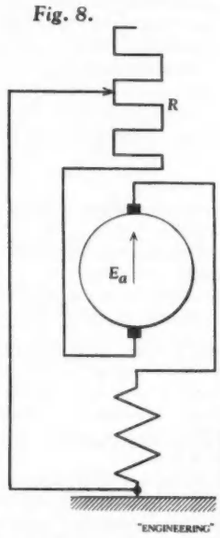


Fig. 8.



(1330.A.) "ENGINEERING"

r.p.m., $\Phi k = 0{\cdot}975$, so that the induced back e.m.f. is then

$$E_a = \Phi kN = 0{\cdot}975 \times 900 = 875 \text{ volts.}$$

The total magnitude of the required braking resistance R_0 (including the armature and field-coil resistance), is then given by the equation

$$E_a = I_{max.} R_0$$

so that,

$$R_0 = \frac{875}{70} = 12{\cdot}5 \text{ ohms.}$$

TABLE I.

Speed, N r.p.m.	Current, I amperes.	Back e.m.f., E_a.	$\Phi k = \frac{E_a}{N}$.
460	80	464	1·01
480	70	468·5	0·975
510	60	473	0·93
550	50	477·5	0·86
620	40	482	0·775
730	30	486·5	0·665
920	20	491	0·532
1,250	10	496	0·396

Now, if this braking current of 70 amperes is required to be maintained constant while the motor slows down, the necessary relationship will be

$$I_{max.} = \frac{E_a}{R_0} = \Phi k \frac{N}{R_0},$$

so that the flux Φ must remain constant and, since k is a constant of the machine, it follows that the ratio $\frac{N}{R}$ must remain constant; that is to say, the resistance must be reduced proportionally with the speed. This required relationship is defined by the straight line A O in Fig. 9.

Next, suppose that for the same initial speed of 900 r.p.m., the braking current is to remain constant at the value $I_{min.} = 40$ amperes. This will require an initial value for the resistance of R_0 ohms such that

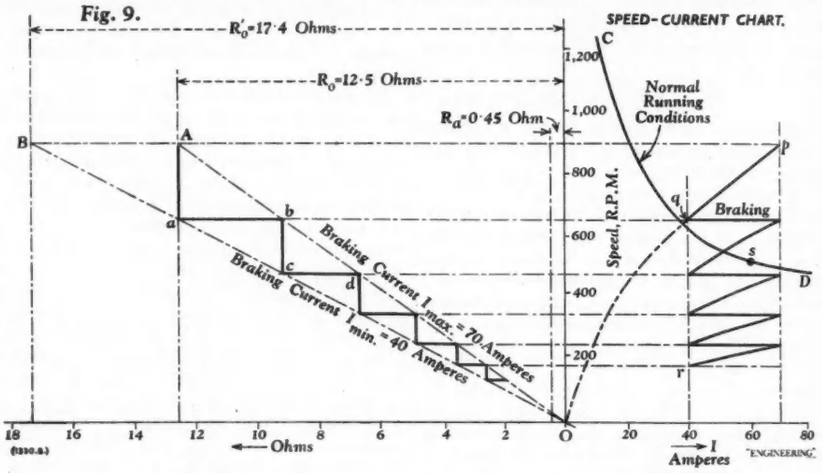
$$R_0' = \frac{E_a}{40} = \frac{0{\cdot}775 \times 900}{40} = 17{\cdot}4 \text{ ohms.}$$

Since, from Table I, it is known that

$$E_a = \Phi kN = 0{\cdot}775 \times 900 \text{ volts,}$$

and, by the same argument as that given in the previous case, it is found that, in order to maintain the current constant at the value of 40 amperes throughout the braking period, the relationship between the speed and the resistance must be that defined by the straight line B O in Fig. 9. In practice, it would not be feasible to adjust the resistance R to the speed of the motor in accordance

Fig. 9.



with the relationships shown by the lines A O and B O of Fig. 9, and the method adopted is as follows.

Starting with the braking resistance $R_0 = 12{\cdot}5$ ohms and the speed 900 r.p.m., the current will be 70 amperes, as already found, and these numerical values will then correspond to the point A on the straight line O A. The current will then fall while the resistance remains constant at the value of 12·5 ohms. When the current has fallen to 40 amperes, the conditions will correspond to the point a, Fig. 9, since the straight line B O has been drawn to correspond to a current value $I_{min.} = 40$ amperes. When the current has fallen to 40 amperes, a section of the braking resistance must be cut out, so that the current rises again to the value $I_{max.} = 70$ amperes, and a little consideration will show that the magnitude of the resistance section which must be cut out is that which corresponds to the horizontal straight line $a\,b$, Fig. 9, that is, (12·5 — 9) ohms = 3·5 ohms.

The current then again falls as the motor speed falls and when the value $I_{min.} = 40$ amperes is again reached, as defined by the point c, the resistance section $c\,d$ must be cut out, thus causing the braking current to rise to 70 amperes as defined by the point d. This procedure is continued in accordance with the routine explained, and as shown by the stepped line in Fig. 9, until some sufficiently low speed has been reached which will be appropriate for the application of the mechanical brake.

The relationship between the speed and current is shown by the curve $p\,q$ in Fig. 9, and it is of interest to consider how this curve has been derived. The conditions are that the resistance remains constant at 12·5 ohms. Then reference to Table I shows that, when the current has fallen to 40 amperes, the factor $\Phi k = 0{\cdot}775$ and $E_a = 40 \times 12{\cdot}5 = 500$ volts. It then follows that the speed is

$$N = \frac{500}{0{\cdot}77} = 648 \text{ r.p.m.}$$

and this is shown by the point q in Fig. 9.

In a similar manner, the whole curve $p\,q$ O has been derived, the resistance of 12·5 ohms remaining constant for the portion $p\,q$ and being then cut out step by step as already explained for the range from 900 r.p.m. to 648 r.p.m.

A disadvantage of this method of braking is that if the switch does not open at the correct moment to cut out a resistance section of the appropriate magnitude, it is possible that an excessively high current will flow, and this will not only seriously damage the commutator, but also cause heavy jerks on the vehicle.

The continually increasing speeds of street and railway traffic have made it necessary to give much greater attention to the problems of smooth electric braking. For example, in the above-described method of braking, it was formerly considered that from 10 to 12 starting sections, and from 6 to 7 braking sections were adequate for tramway work, whereas the modern view is that there should be about 22 starting sections and about 15 braking sections.

For electric braking, the motors operate as generators, the mechanical energy of the vehicles being converted into electrical energy. This energy must be dissipated or utilised in some way. For this purpose there are two possibilities, namely, resistance braking and regenerative braking, each method having its own advantages and disadvantages. For regenerative braking, the braking energy is returned to the supply lines, so that, at least in part, this method has economical advantages. It is, however, essential that the motors should be able to return the energy to the line in the same form as the supply, that is, at a frequency of 16⅔ cycles, and this involves special auxiliary apparatus. A further vital consideration is that the system is dependent on the supply lines, and that the regenerative braking action is only operative so long as the supply voltage is maintained and the regenerated power can be utilised elsewhere in the system. An unintentional interruption of the supply voltage during regenerative braking can be highly dangerous.

With resistance braking, the electrical energy is converted into heat, and the difficulty then is to provide adequate cooling for the resistances. On the other hand, this type of braking is independent of external conditions. Moreover, the type of current can be chosen as desired. The energy may be direct current and this is advantageous for the motor. In order to be absolutely reliable, the excitation may be provided by a battery which is nearly always installed for other purposes. In this way, the possibility of failure of the braking action is practically eliminated. For reasons of safety, therefore, when electric braking is used, unless there are good reasons to the contrary, resistance braking should be employed.

THE IRON AND STEEL INSTITUTE.

(*Continued from page 597.*)

CONTINUING our report of the annual general meeting of the Iron and Steel Institute, held in London on Thursday, April 30, and Friday, May 1, we have now to deal with the proceedings which followed the induction of the new President, Mr. James Mitchell, C.B.E., and the delivery of his presidential address, on the first day.

RAILWAY TRAFFIC IN STEELWORKS.

The first two papers on the agenda were taken together for discussion. They were entitled, "Train Arrivals, Handling Costs, and the Holding and Storage of Raw Materials," by Mr. M. D. J. Brisby and Mr. R. T. Eddison, and "Railway Traffic of the Appleby-Frodingham Steelworks," by Mr. E. R. S. Watkin. In their contribution, which was a paper of the Civil Engineering Committee of the Plant Engineering Division of the British Iron and Steel Research Association, Mr. Brisby and Mr. Eddison stated that the sizes of trains arriving at an integrated iron and steel works were not constant, and calculations could not be based on the expectation of trains of a particular size. The number of wagons per train was found to vary from less than 5 up to 80, with an average of about 33. There was a definite tendency for trains to arrive between 5 and 6 a.m., between 8 and 10 a.m., between 1 and 5 p.m., and at about midnight. If congestion were to be avoided, the reception sidings should be large enough to accommodate the average arrivals during two shifts, a figure borne out by practical experience. The distribution of arrivals of the three principal commodities—ore, coal and scrap—did not in any way conform to a common pattern. Coal arrivals appeared to be particularly scattered, but closer examination showed that there was a distinct weekly cycle, with heavy arrivals towards the end of the week. The greatest economy would nearly always be obtained with siding capacity such that wagons were retained in the works on the average for rather less than the effective free standage period of 1·5 days. To maintain an average turn-round time of 1·5 days, the holding sidings for main inward commodities needed to hold between 3½ and 5 times the average daily consumption. Sidings of this capacity should provide an adequate margin for irregular arrivals.

Mr. E. R. S. Watkin, who is railway traffic manager at the Appleby-Frodingham Steelworks, stated in the course of his paper that the inward, outward and internal railway traffic at these works amounted to 268,750 net loaded tons per week, that there were 100 miles of internal railway and that the works rolling stock comprised 1,841 wagons and 55 locomotives. The local limy Frodingham ore of 20 to 22 per cent. iron content formed three-fifths of the ironworks raw material, and was delivered by private haulage of the associated ore-mining branch to sidings at the works boundaries. Coal for the coke ovens and bought coke came mainly from South Yorkshire. The coal was unloaded by tippler from a variety of British Railways 12-ton to 20-ton wagons; the coke was unloaded at a separate gantry for each blast furnace. The main works output of steel plates and sections departed westward via Stainforth, or eastward via Barnetby. The weekly net tons hauled comprised: inward 25·3 per cent.; outward, 8·8 per cent.; and internal, 65·9 per cent.; and loads were hauled through an average distance of 1·28 miles. All tracks in general use were capable of carrying axle loads of from 30 to 35 tons. With weekly arrivals of 4,390 loaded wagons and weekly departures of 640 loaded wagons in re-used empties and 1,560 in received empties, the average free terminal time was only 1·26 days. This stringent limit, however, was not attainable regularly and during the last financial year, the actual weekly terminal time for the inward and outward traffic averaged 1·5 days, with a minimum of 1·1 days and a maximum of 2·1 days.

Mr. R. T. Eddison, who in the absence of Mr. Brisby owing to illness, presented the first paper, mentioned that as the contribution had been written some time ago it contained no reference to the new 27-ton ore wagons developed in collaboration between British Railways and the Transport Committee of the British Iron and Steel Federation.

DISCUSSION.

Mr. W. MacLester, who opened the discussion, stated that in modern steelmaking one of the essential factors, if not the most important factor, was that of handling. Mr. Watkin's detailed account of the Appleby-Frodingham railway traffic was of the greatest interest. From one point of view, his (Mr. MacLester's) firm, Stewarts and Lloyds, Limited, at Corby, were in a similar position, in having to handle a very heavy load of ore and other materials. Corby now produced between 14,000 and 15,000 tons of iron a week, which meant that over 40,000 tons of material has to be provided for the ore-preparation plant, and 12,000 tons of sinter has to be dealt with. The total number of wagons handled out of the works had increased from 392,000 in 1948 to 501,000 in 1952. Over the same period the blast-furnace output had increased by approximately 50 per cent., and the figure for slag ladles had risen from 175,000 to 204,000 in the same period, although the ladle size had also increased. At Corby, 30 locomotives were operated, including two Diesels. From actual figures obtained from these two locomotives, one a 200-h.p. Diesel-hydraulic and one a 400-h.p. Diesel-electric, they were convinced that there were considerable monetary savings to be made as well as other advantages to be gained by the use of Diesels. This conclusion had been confirmed in other works.

Another adjunct to future traffic operation was radio-communication. This was, as yet, in the experimental stage in this country, and results so far showed that with the present development of apparatus the scope was extremely limited. The expensive equipment which had to be provided would not replace the outside foreman, and the full benefit of radio telephony for this purpose would not be obtained until there was, on the market, a transmitter sufficiently compact to be carried in comfort by a pedestrian. One point which the author did not mention, but which was of some importance in maintaining traffic efficiency, was the recruitment of future traffic personnel. Shunters should be young men, but unfortunately the right type was not attracted by shift work, and the wages offered were often below those paid in the production departments, so that there was a tendency for the men on whom reliance would ultimately have to be placed, for the efficient execution of the work, to fall below the desired standard.

The paper by Mr. Brisby and Mr. Eddison was most stimulating in its approach to the problems of siding capacity. The fact that the majority of existing works had a far from perfect layout had to be accepted as a starting point, as numerous factors in the past, many of them insurmountable, had led to that state of affairs. Nevertheless, the theoretical principles laid down in the paper focused attention on certain traffic matters, improvements in which, whether by track modification, site alterations, or even a better form of administrative control, would result in saving time and money. The control system at Corby was based on a daily standage figure for each commodity, fixed by the general manager. A report sheet was submitted each morning showing the actual standage compared with that laid down, and any appreciable deviations were investigated by the traffic department in conjunction with the appropriate plant manager. Where any change was found to be necessary the buying department were asked to make the necessary alterations in the future supply. This system, which was essentially flexible, had worked very well; and although, as mentioned earlier, the number of wagons handled had greatly increased over the last few years, the standage charges had been maintained as before and, in some cases, even reduced.

The supply of coal for coke ovens was a problem in itself, in that large stocks had to be carried to cover colliery holidays and other seasonal fluctuations. It seemed that there was a definite deterioration in quality owing to long stacking times. The new system of colliery holidays aggravated this position, and it was a matter of some importance to reconcile these opposing factors. The provision of a coal bedding and preparation plant went some way to provide such a solution.

Mr. A. J. Harby said that Mr. Watkin had not mentioned the problem of where road and rail haulage could meet in an iron and steel works. They, in the Steel Company of Wales Limited, were finding that these could be complementary, and that the motor lorry was proving itself to be an economical and also a time-saving method of moving the smaller, urgently-required loads, particularly the engineering requirements, and also of handling the disposal of slag. There was moreover the increasing tendency to despatch steel products, and particularly sheet, by road. His company had been using wireless for about two years, and particularly where ingots were being delivered from two or more melting shops to a common stripper bay, it was invaluable. This traffic was controlled by one man on each shift; he was at the top of the building and in complete telephonic communication throughout the shift with the melting shops, the mould bay—he could see the stripper bay—and the steel planner in the soaking pits, and he could direct his locomotives to deal with the varying requirements which arose in an open-hearth process. Without wireless, this could not be done by one man.

Lastly, on the question of locomotives. At present they were running a fleet of steam locomotives and also a fleet of Diesels, and they were beginning to be able to make a comparison between them. It was too early yet to be definite; it was probably fair to say that seven or eight years were needed before a true cost of maintenance was obtained. However, in the two-and-a-half years during which they had had the Diesels working, they were beginning to get a fair indication. Excluding from the running costs manning charges as they varied in different works, the advantage of the Diesel as compared with the steam locomotive was found to be of the order of 10*s.* per locomotive hour.

On their latest 0-6-0 steam locomotives, which had been running now for just under two years, roller bearings had been fitted throughout, including the side rods. To date that had meant a great saving in repair costs. There was hardly any wear to be seen on the side rods, and, so far as the pistons were concerned, it had not been necessary to look at the bearings.

Mr. M. G. Bennett said that a superficial examination of the frequency of arrival of trains of scrap and coal, and so on, might lead to the supposition that there was no planning whatever behind railway operations. Of course, with an undertaking so complex as a railway there must always be many random influences operating. British Railways very often obtained co-operation from their traders, but that was not a matter over which they had any absolute control. Passenger trains had to be run at certain times of the day, and other trains had to be fitted in as well as possible in between. The net effect looked rather like the curve which would result from a completely random despatch of trains, but that did not mean that things were not planned in so far as it was possible to do so. In the matter of storage and the turn-round of wagons, it would appear from the paper by Brisby and Eddison that it was in the interests of British Railways and of the iron and steel industry to do what was economical, and to reduce standage even below the figure at which free standage was obtained. The conclusion of the paper was that, by and large, it would pay to reduce the free standage of 1½ days to an even smaller figure, and also that if material were to stand in store for a long time as a buffer it should be unloaded rather than stored in wagons. He wondered whether some of the apparently conflicting evidence which existed on the question of steam versus Diesel locomotives might not be explained by the different loads with which they had to deal. The characteristic curves of steam and Diesel locomotives, comparing fuel consumption with load, differed, and it might be found that Diesels were more efficient when there were a large number of small loads to move, while steam should be reserved for the larger trains. That had been the case in some instances on British Railways.

Mr. M. F. Barnard said that although it was not to be expected that sidings would have been altered very much during the last seven or eight years, the iron ore conveyed by British Railways had gone up from 6½ million tons in 1947 to 10¼ million tons in 1952. On what plan had that been dealt with? Had it been by the wagons being kept under load or by the handling of traffic into store? In any case, the results achieved had been excellent. Mr. Eddison had said that he and Mr. Brisby had not been able to take into account the 27-ton wagon. The 27-ton wagon had come to stay, and about 3,000 of them were in operation. The larger hopper wagon had also come to stay, and there were only about 14 per cent. of them which had not a carrying capacity of at least 20 tons. It was understood that there was to be a change in the loading of trains of 27-ton wagons. At present, with fifty 13-ton wagons, the load would be 650 tons, but with the 27-ton wagons there had been a limit of 378 tons. This was now to be raised to 675 tons.

Mr. C. Hulme stated that a large steel company in the North of England had developed a 45-ton hopper wagon running on two axles. This struck him as being the largest load which it was physically safe to deal with in this manner. The latest wagon at Appleby-Frodingham, in comparison with this, carried 30 tons, and the average for other steelworks was very much less. He would like to ask Mr. Watkin whether he considered that this 45-ton wagon was likely to be a successful venture, and whether he had any thought of adopting it in his own works? Lighting by towers had come in for adverse comment, but this form of lighting was undoubtedly satisfactory in districts where fog and mist were conspicuous by their absence. With regard to the tipping of slag ladles, opinion at Appleby-Frodingham had been against power tipping, which was performed there by steam. At the Margam steelworks a similar type of ladle was tipped by compressed air, the compressors being permanently sited on the slag bank, and this method had proved very satisfactory. There were three possible modifications of this method. The first was tipping by air compressor on a Diesel locomotive—namely, the compressor used for the brake gear. The second was tipping by a compressor carried on a car in front of the locomotive and travelling with each train, and the third was tipping by mobile compressor on the slag bank itself. The Steel Company of Wales had used the third method only as an emergency method in the case of breakdown of the normal equipment.

For the first time this year, up to 60,000 tons of coal would be held on the ground on account of the miners' fortnight holiday. Hitherto, 25,000 tons has been the maximum, and before the new coke ovens were built it had been possible to hold an accumulation for the holiday period on wheels. With regard to alternative handling methods and future procedure, a new stock ground, particularly for coal, was at present under consideration. This would hold 100,000 tons of coking coal in two age-groups, with six varieties in each group.

Arisings of shale from the coal washery and spoil from excavations made by contractors, and so forth, were handled by motor lorry. Where large quantities were involved, as from the melting-shop pit side during furnace demolition, 50-ton ore dump cars were in use. On the question of traffic operation generally, he could confirm what Mr. Harby had said concerning the value of the motor lorry. The iron and steel works of the future would no doubt use rail track and locomotives for handling the bulk production materials, but road transport would be used more and more for handling maintenance material, and for dealing with the smaller individual quantities of miscellaneous materials.

The President, in closing the discussion, stated that from their own experience, at Corby, the question of the employment of Diesel locomotives was more likely to be answered in the board-room than in the works, because capital cost was a consideration. On the question of road haulage, they had had recent experience of a successful change-over from wagon to lorry for the handling of flue dust from the furnaces, and there must be many other places where that could be done.

Mr. R. T. Eddison, in reply, said that there had been no intention of suggesting that there was no planning on British Railways, but the figures for receipts into actual works showed that the arrivals were uncomfortably random. The moral was that anything that could be done, either by British Railways or, and particularly, by the consignor, to regularise arrivals into the works would be a great help to steelworks managers. The Coal Board was in some ways especially bad in this respect; the figures showed that an enormous build-up of coal arrived on Thursdays and Fridays, with very small loads at the beginning of the week.

Mr. E. R. S. Watkin, in reply to the discussion on his paper, said that various speakers had asked regarding floodlights. There was much that was attractive in the idea, and it had been installed in one area in Frodingham; it had been taken down, however, in the "blackout" and had not been put back again since. Although a few very high towers could provide better lighting under normal conditions, the big disadvantage was that if there was fog, of which they had a good deal, the lighting was cut off entirely. A large number of lamp-posts at comparatively frequent intervals did not provide such good lighting under normal conditions, but in fog they were still visible as landmarks and helped people to know where they were. On the subject of Diesel locomotives, his attitude was guarded, but not antagonistic. In his view, the true equivalent of a well-built 16-in. 50-ton steam locomotive was probably nearer 400 h.p. than 300 h.p.

There was one other factor, which came out in the course of Mr. Bennett's remarks. The Diesel locomotive had a running cost which varied with the amount of work done. The steam locomotive—and this was perhaps one of its bad features—had a running cost which was not so closely associated with the work that it carried out, but went by time alone for the most part, so that the more intensely a steam locomotive was used, the less badly it showed up in comparison with the higher thermal efficiency of the Diesel engine.

The question of using radio had been examined very carefully. Much depended on the shape of the works. Functionally, Appleby-Frodingham had the shape of a cartwheel, with the main-line connections and slag tip on the periphery and the main internal communications, including those for ingots, through the hub, so that the distances over which the ingots were moved were rather less than in a works having a long or ribbon-like shape. It was for that reason, perhaps, that it had not been necessary in their case to use radio for ingot control; they had found that the telephone from the steel control was quite satisfactory. He agreed that there were quite a number of directions in which road transport was a valuable addition to the means of handling greater tonnages in the works. For all the odds and ends to do with maintenance traffic it was invaluable, and released the higher capacity of railway traffic for more important purposes.

Mr. Hulme had referred to the 45-ton wagon. They had designed and were now building 31-ton wagons for local ore traffic, which passed, on a toll basis, over part of British Railways. They had been allowed a 40-ton gross weight on two axles, and that was the basis of the figure of 31 tons, namely, 31 tons plus 9 tons tare. Had it been for purely internal purposes they might have been tempted to go higher. He hoped that the tendency to upgrade the axle loadings would continue gradually, both internally and on British Railways. They had never felt happy about the power-tipped ladle and had persistently experimented for a few years with a simple type of rope-tipped ladle. It had the same capacity as the normal steam-tipped ladle, and cost very much less. On the subject of standage, he could confirm the fact that the 1½-day target was not a spurious one. It was a perfectly genuine calculation that 1½ days was a desirable optimum, taking into account the storage and the wagon costs, and it was not coloured at all by the fact that 1½ days was the apparent free limit. It was, however, a very difficult figure not to exceed, and a great deal depended on the development of store grounds which were separate from the actual plant operation.

(To be continued.)

WATER AND THE ATOMIC ENERGY INDUSTRY.

A PAPER on the implications of the effect of the atomic energy industry on water supplies was presented at the Summer General Meeting of the Institution of Water Engineers, held at Southend-on-Sea on May 13, 1953; the authors were Mr. A. Wolman of Johns Hopkins University, Baltimore, and consultant to the United States Atomic Energy Commission, and Mr. A. E. Gorman, sanitary engineer to the Commission.

The authors said the processing of fissionable material did not give rise to high water requirements, but that in the reactors in which fissionable material was bombarded by neutrons to establish controlled reactions, prodigious amounts of heat were generated, which had to be removed, usually by water, to prevent damage to the reactors. In water-cooled reactors of the Hanford type, water was passed through the reactor once only, and was then retained in a basin to permit the decay of short-lived fission products, before it was released back to the river, very large quantities of water being used. This water, however, had first to be treated to remove all suspended matter and other substances in the river water, which, if irradiated in the reactor, would complicate the problem of disposal of the water and its return to the river; some of the largest water-treatment plants in the United States, therefore, were serving these reactors. In other reactors the cooling-water was re-circulated, the heat being removed by cooling towers.

The authors gave some findings on how best to treat water which had become contaminated by radio-active materials, and these findings are produced below in full:—

"(1) Local clays remove variable amounts of radio-active materials from solution. The addition of 100 parts per million of clay removes as much as 80 per cent. of Cerium^{144}, 46 per cent. of Yttrium^{91}, 34 per cent. of Phosphorus^{32}, 30 per cent. of Strontium^{89}, and 29 per cent. of Iodine^{131}.

(2) Similar variations in performance occur in orthodox coagulation with alum and sodium hydroxide.

(3) Only slight increases in removal are accomplished by the joint use of sodium carbonate and alum.

(4) The artificial addition of clay, with alum coagulation, again only slightly increases these removals.

(5) Alum coagulants, with the addition in some instances of small amounts of activated carbon, copper sulphate or silver nitrate, improve materially the removal of Iodine^{131}.

(6) The phosphate coagulant with *p*H control results in one of the best performances.

(7) Phosphorus^{32} is successfully removed by orthodox combinations of coagulation, settling and filtration, while Iodine^{131}, as might be anticipated, resists effective removal.

(8) Perhaps one of the most significant findings is that approximately 70 per cent. of radio-active materials normally found in the fission products mixtures could be removed by familiar water treatment procedure."

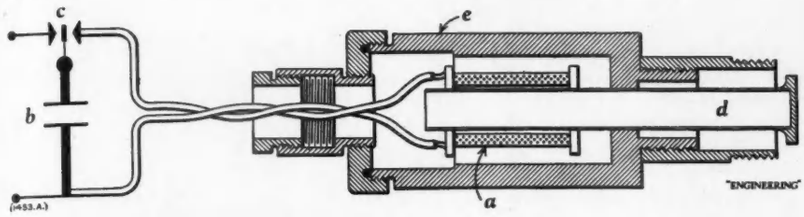
Various other methods were mentioned as having been used for decontamination of water, such as the use of ion-exchange materials and metallic wool, and slurrying with powdered metals. The capacity of lime crystals to absorb radio-activity was under study and research was proceeding on the capacity of slimes and algae to act as absorbents.

In the matter of standards for palatable water, the authors pointed out that the possible sources of contamination were increasing with the increased use of radio-active isotopes in hospitals, research laboratories and industrial plants. There was one level of radio-activity applicable to those waters which might be consumed over a lifetime and another applicable during a short period of emergency, and they gave figures of the permissible levels of radio-activity. The day would surely come, the authors concluded, when the use of radio-active materials in industry would be far more widespread, and it therefore behoved the water engineer to familiarise himself with the products and processes of this industry.

ULTRASONIC BOILER DESCALER.

H.N. ELECTRICAL SUPPLIES, LTD., LONDON.

Fig. 1.



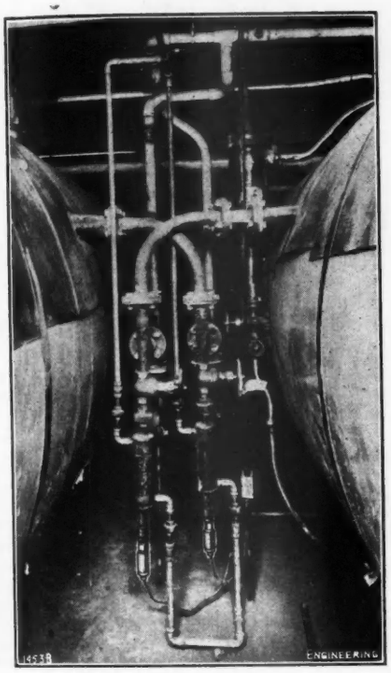


FIG. 2. DESCALING APPARATUS FITTED TO TWO BOILERS.

THE "CRUSTEX" ULTRASONIC BOILER DESCALER.

THE "Crustex" boiler descaler, which is manufactured by H.N. Electrical Supplies, Limited, Brixton Hill-place, London, S.W.2, utilises ultrasonic pulses to prevent and break up the scale forming in boilers and other similar equipment. It operates on the principle that the scale and the metal upon which it is deposited have different moduli of elasticity, so that the effect of the pulses is to cause the former to fracture and flake off. The equipment comprises a simple transformer and rectifying circuit, which is housed in a dust-proof metal case and supplies an oscillating circuit which generates direct-current pulses at a frequency of 28,000 cycles per second. As shown in Fig. 1, this oscillating circuit, which is mounted on the boiler, is made up of a nickel-plated brass cylinder 1½ in. in diameter and 5 in. long, which contains a nickel tube *d*, surrounded by solenoid *a*. The condenser *b* is charged from the generator and discharged through the solenoid by the mercury commutator *c*. The current pulses in the solenoid produce magneto-striction in the nickel tube *d*, the midpoint of which is brazed to the oscillator body *e*. This body is, in turn, screwed to some convenient point on the boiler. The effect of the magneto-striction is to produce damped pulses in the nickel tube, the mid-point of which forms a node in the vibrating system. These pulses are then transmitted into the water by the free end of the tube, which is closed by a metal disc, as shown at the right of Fig. 1.

The generator is designed for connection to the 200/250-volt, 50-cycle mains, and has a consumption of 20 watts, which is sufficient for the supply of four oscillators. The mercury switch consists essentially of a U-shaped quartz tube, each arm of which is surmounted by a bulb containing hydrogen gas. Each bulb also contains an electrode the lower end of which is just above the mercury when the switch is in the static condition. In addition, one of the bulbs carries a tungsten filament which dips into the mercury. When the current is switched on this filament becomes hot, so that the hydrogen expands, thus depressing the mercury in one arm of the U-tube and raising it in the other. The result is that the mercury is set in oscillation and alternately makes and breaks contact with the electrodes, a condition which persists as long as the apparatus is switched on.

A typical application of the descaler is shown in Fig. 2, which illustrates the apparatus fitted to two hand-fired Danks "Super Economic" boilers with a rated output of 3,000 lb. per hour at a pressure of 100 lb. per square inch. In both cases the oscillator is installed in the feedwater connections and is provided with a water jacket to ensure its effectiveness in case of a rise in temperature. Generally, the system is applicable to plant operating at pressures up to 450 lb. per square inch and with rates of evaporation up to 15,000 gallons per hour for water of average hardness. Under such conditions, it is stated, the scale is removed continuously, only a deposit of eggshell thickness being left on the tubes and plates.

SURFACE PLATES OF GRANITE.

A RECENT test at the Metrology Division of the National Physical Laboratory has pointed out the advantages of granite, or diabase (a fine-grained, compact, crystalline granular rock) as a material for surface plates. These advantages include freedom from corrosion, stability and extreme hardness. In addition, there is no burring if a heavy object is dropped accidentally on the plate. In the test, a granite surface plate was used alongside a cast-iron surface plate as a work support on a spot grinder, the work being slid backwards and forwards on the plate under the grinding wheel. The test was carried out for six months under these arduous conditions, the plates being used alternately. At the end of the test there was no measurable wear on the granite plate to within the accuracy of measurement, about $\pm 0{\cdot}00005$ in. The wear at the centre of the cast-iron plate was of the order of 0·0004 in. The Division emphasises that the test was not considered to be scientifically controlled, but the results indicated the superiority of granite over cast iron as a wear-resistance material in this particular application.

Granite and diabase surface plates are popular in the United States since, apart from their advantages, the difference in price between them and cast-iron plates is small. Little is known about the mineralogical composition of the material from which satisfactory plates have been made, and some care is probably necessary in selecting a suitable grade of material. The manufacture of granite surface plates has now been started in Great Britain by Lithinof Precision Surfaces, 85, Mayfield-road, Acocks Green, Birmingham, 7.

RESEARCH STATION FOR RURAL ELECTRIFICATION AT SHINFIELD.

THE British Electrical and Allied Industries Research Association, whose headquarters are at Leatherhead, Surrey, and main laboratories at Perivale, Middlesex, established a rural-electrification section in 1938 for the development of equipment and operating techniques which would be satisfactory to farmers and growers and also present load characteristics favourable to economic electricity supply. After the termination of the war in 1945, a Field Station was established at Shinfield, near Reading, Berkshire, to provide facilities for research work on a practical scale; and, in order to enable members of the Association and others interested to see something of the work being done, a series of five "open days" was held at Shinfield last week from May 4 to 8, inclusive.

The "open days" were inaugurated on Monday, May 4, by Mr. G. R. H. Nugent, M.P., Parliamentary Secretary, Ministry of Agriculture and Fisheries, after some introductory remarks by Mr. C. T. Melling, chairman of the Council of the Association, and a vote of thanks to Mr. Nugent was proposed by the Director, Dr. S. Whitehead, M.A., M.I.E.E., F.Inst.P. The visitors were then conducted round the Station, which has an area of about three acres and is divided into two parts, one occupied by laboratory and workshop buildings, the other, and larger part, being used for research work. In this area there are two main greenhouses, divided internally into compartments for experimental purposes, and three smaller greenhouses. There are also a number of experimental plots, some provided with Dutch-light frames or cloches and others in which the growing crops are uncovered; in most of the plots the necessary equipment for soil warming by means of buried conductors is provided. In an adjoining field the poultry department of Reading University is accommodated and in this experiments undertaken jointly by the University and the Association are carried out. Researches are now being conducted on the effect of temperature and humidity on the development of chicks, and the effect of flash illumination on laying poultry is also being studied.

In one of the large glasshouses, which as previously mentioned is divided into compartments, the six compartments formed are used for propagating purposes and are heated by a low-voltage conduit installation. At present, experiments are being carried out on the effect of supplementary artificial lighting on tomato seedlings using different light sources, including neon, mercury, sodium fluorescent and tungsten lamps. After treatment, selected samples are planted out in the other house and grown to provide data, from the cropping records, on the responses of the plants to the treatment. Other compartments are being used for growing tomatoes with and without soil warming and with two different night-air temperatures. So far, it appears that the same total crop is obtained at the lower air temperature with soil warming as at the higher temperature without soil warming, but the crop is a little later.

The Station includes an installation of 45 frames, part of which is shown in Fig. 1, on page 620, in which the soil is warmed by twin galvanised-steel wires carrying current at about 20 volts supplied from a transformer housed in a hut shown on the right. Resistors are fitted to the frames to enable the electrical loadings and "dosages" to be adjusted. The usual daily "dose" is from 40 to 45 watt-hours per square foot of surface. Experiments have been made in these frames to determine the effect of different daily doses and planting dates on lettuces. To investigate the economy of soil warming on crops grown out of doors, an area has been divided into 18 parts so that six replications of three different treatments can be investigated. At present, the responses of various crops to two levels of soil warming with dosages of 90 and 60 watt-hours per square foot *per diem* are being compared with similar crops on the control plots which are not heated. Somewhat similar experiments are being carried out with soil warming

RESEARCH STATION FOR RURAL ELECTRIFICATION AT SHINFIELD.

FIG. 1. PROPAGATING FRAMES WITH SOIL HEATING.

FIG. 2. ELECTRICALLY-OPERATED TRACTOR.

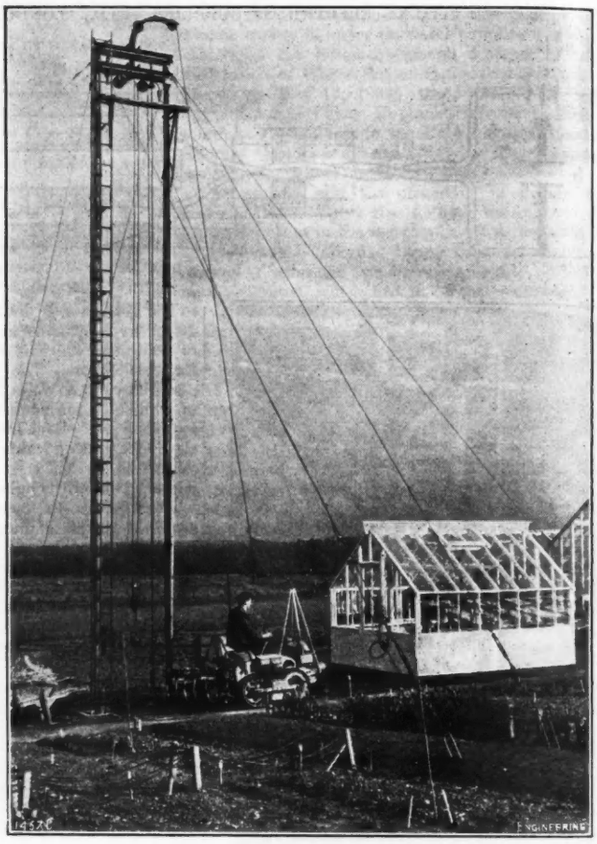


FIG. 3. CABLE TOWER FOR TRACTOR.

under cloches, different arrangements of warming wires being used.

To facilitate the measurement of soil and air temperatures in different parts of the Station, a temperature-measurement hut has been erected in a central position, to which leads from copper-constantan thermocouples are brought. For soil-temperature measurements the junctions are immersed in oil at the bottom of glass tubes inserted in the soil, and for measuring air temperatures the junctions are shielded by small metal open-ended cylinders. A potentiometer is provided in the hut and this can be quickly and conveniently connected to any one of 250 thermocouples. A thermostatically-controlled reference junction is employed, but, as an alternative, a water tank buried 2 to 3 ft. below the surface of the soil can be used, this having the advantage of obviating the need for a supply of ice for a crushed-ice cold junction.

Although most of the work at Shinfield is concerned with the encouragement of the growth of plants, it is sometimes necessary to destroy them, as, for example, in the "singling" of sugar beet and other root crops. Portable apparatus has been devised for this purpose and is shown in use in Fig. 4. It consists of a metal probe carrying a current, the probe being pressed into the plant or weed and rapidly destroying it. Experiments are being carried out on the destruction by similar means of deep-rooted weeds such as bracken, but this work is at present in an early stage and much still remains to be done. It is hoped that the method may be useful for destroying bracken on hilly land where mechanical cultivation is impracticable.

An interesting small-scale demonstration of the destruction of weevils in grain by high-frequency electric fields was being given in one of the laboratories. The method has the advantage that the heating effect of the field on the insects is sufficient to destroy them, but does not injure the grain. A

FIG. 4. ELECTRICAL DESTRUCTION OF WEEDS.

frequency of 14·5 megacycles per second was used for the demonstration, but we understand that a higher frequency of, say, 20 megacycles would be preferable. The conditions requisite for the large-scale application of the method and its economic possibilities are being studied. Another matter that is being investigated is the possibility of sterilising soil in glasshouses by passing a low-voltage current through it by means of rod electrodes. The effects of soil density, moisture and resistivity have already been studied using a single electrode, but the effect of adjacent electrodes is now being investigated and the method will then be tested under practical conditions in the glasshouses with a suitable arrangement of electrodes.

The matter of drying seeds and crops is of great importance to farmers and is being given considerable attention at Shinfield. An experimental portable seed drier has been designed and trials will be carried out on farms, with threshed and unthreshed seed samples. The control equipment enables air of a pre-determined relative humidity to be circulated through the sample and if the relative humidity of the atmosphere should reach a lower value than is required the supplementary heat is cut off automatically. Otherwise the minimum of heat is supplied to give the air circulated the required humidity. Crop drying is studied in a special laboratory equipped with apparatus for determining the drying characteristics of various materials. The sample under investigation is weighed continuously; the rate of airflow, which is measured by a hot-wire anemometer, and the temperature and humidity of the drying air can be varied over a wide range. The depth of the sample can also be varied up to a maximum of 1 ft. An experimental crop drier has been used at Shinfield to study the effect of wilting wet grass without employing supplementary heat. Relatively large volumes of cold air are first blown through the grass to reduce its moisture content from 80 to 50 per cent. and the drying of the wilted grass is completed with a greatly reduced flow of warm air. The grass container is supported on hydraulic mechanism to enable the weight of its contents to be recorded throughout the drying cycle.

Considerable interest was taken by the visitors in the electrically-operated tractor which has been used for about four years for all the normal cultivation and haulage work of the Station. The current required is taken from a central tower through a cable which is kept taut by a weight and pulley system clearly shown in Fig. 3. The radius of action of the tractor is about 110 yards from the

"PROFILOSCOPE" FOR EXAMINING WIREDRAWING DIES.

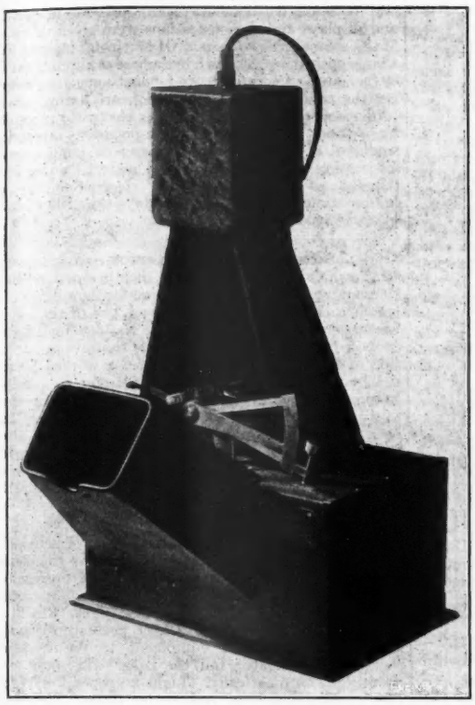


FIG. 1. PROFILOSCOPE.

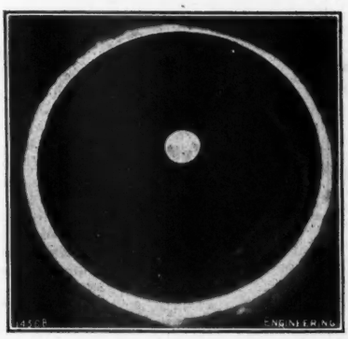


FIG. 2. UNSCORED DIE.

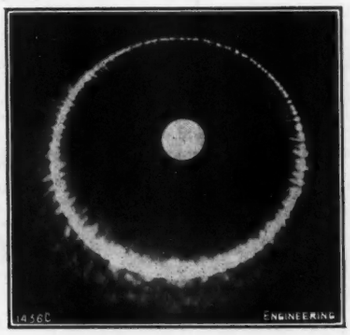


FIG. 3. SCORED DIE.

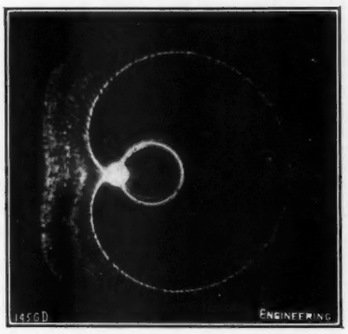


FIG. 4. MEASURING THE DIE ANGLE.

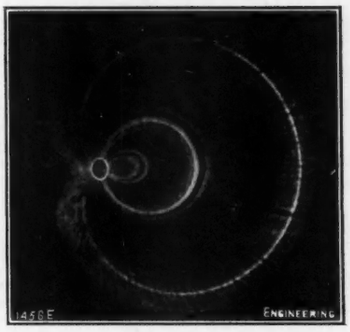


FIG. 5. PARALLEL SIZING PORTION.

tower, so it could operate over a square-shaped area of five acres; the minimum distance of the cable from the ground is 3 ft., enabling work to be done in standing crops. The tractor itself, shown separately in Fig. 2, has not been specially designed for the purpose, having been adapted from a petrol-driven commercial machine. The main object of the work is to determine the best method of getting a supply of current to the tractor. A specification for a cable, light enough and with sufficient strength in tension, has been drawn up and three alternative designs are under test or are being manufactured.

Another item of technological interest forming part of the equipment of the Station is the heat-pump installation, which is used to heat one of the two laboratory buildings and also to supply useful experimental data. As the other laboratory building has similar thermal characteristics but is heated by more conventional methods, comparisons between the two heating systems are facilitated. The low-temperature heat for the heat pump is obtained from the surrounding ground, being collected in brine tanks, and the heated water is stored at a temperature of 120 deg. to 125 deg. F., in an insulated tank from which it is circulated through panel-type radiators under the control of a time switch. The heat pump is driven by a 7·5-kW motor, but up to 28 kW is available for heating the laboratory building, representing a performance energy ratio of 3·8. Another application of the heat-pump principle is being investigated experimentally in connection with milk cooling. The object of these experiments is to determine the amount of water that can be raised from the mains temperature to 130 deg. F. for each gallon of milk cooled.

A comprehensive display illustrating the Association's researches on the generation of electrical energy from wind power was also included among the exhibits. This included a model of Costa Hill, Orkney, on which a 100-kW wind-driven generator has been set up for the North of Scotland Hydro-Electric Board mains. Models and illustrations of various designs of wind-power generators that have been suggested or actually employed were shown, together with examples of anemometers and recorders used in wind surveys. The use which can be made of energy extracted from the wind depends, of course, upon the size of the plant envisaged and the possibility of energy storage. Large plants, it is considered, can be used in conjunction with electrical networks for fuel conservation, while, in the case of small plants, energy can be stored in accumulators. With plants of medium size only a small part of the energy can be stored, the remainder being used for loads having inherent storage characteristics.

In conclusion, it may be pointed out that the work of which an outline has been given above could hardly be carried out without considerable financial assistance from the Ministry of Agriculture and Fisheries. The Association also acknowledges the help received from Reading University and the National Institute for Research in Dairying, in the form of research facilities and advice. The co-operation of farmers and growers has also been invaluable.

EXAMINING WIREDRAWING DIES BY OPTICAL REFLECTION.

THE Profiloscope illustrated in Fig. 1, above, has been developed by the British Iron and Steel Research Association at their laboratories, 140, Battersea Park-road, London, S.W.1, for the workshop measurement and inspection of the internal taper of tungsten-carbide wiredrawing dies. The value of such an instrument can be gauged from the fact that about 5 per cent. of the annual output of steel in the United Kingdom is in the form of wire, varying in diameter from those finer than lamp filaments up to diameters of $\frac{1}{2}$ in., and the quality of the wire produced depends materially upon the correct angle and the condition of the die. Descriptions of a more accurate research instrument, the B.I.S.R.A. Profilometer, have already appeared in ENGINEERING, on page 374, vol. 170 (1950), and on page 9, vol. 172 (1951), and the Profiloscope has been produced as a much simpler instrument for general workshop inspection. It is made by the Longworth Scientific Instrument Company, Limited, Abingdon, Berks., for the inspection of dies for 0000 s.w.g. to 19 s.w.g. wire, and a smaller version, for dies smaller than this range, will be made later.

The Profiloscope comprises three essential elements: a light source in the head of the instrument, a die holder and a semi-opaque viewing screen. With the die clamped vertically in the holder, the light passes directly through the die aperture to appear on the screen as a small bright circle in the centre of an annulus of light reflected from the tapering sides of the die; the image given by an unscored die is shown in Fig. 2. Any change in taper is indicated by a circle of light concentric with the aperture image. Scoring of the die is indicated by radial lines on the image, as shown in Fig. 3.

The measurement of the die taper is made as follows. The die, fixed in the holder, is tilted anti-clockwise until the annulus, distorted into a cardioid, touches the aperture image as shown in Fig. 4. By use of the adjusting screw, to be seen in Fig. 1, the scale pointer is turned to indicate the appropriate die diameter scribed at the beginning of the protractor scale. By then tilting the die in the opposite direction, until the distorted annulus touches the other side of the aperture image, the pointer moves across the protractor to indicate the die angle directly. The angle of tilt, $2e$, is related to the angle of the die taper, $2a$, by the following expression, $2a = 2e + \frac{a+d}{l}$, where a and l are instrument constants, and d is the diameter of the die; by setting the pointer initially, not to zero, but to the diameter correction required, the instrument is made direct reading in respect of the total die angle. As, in practice, both a and d are small compared with l, the Profiloscope readily achieves its designed accuracy of 0·5 deg. When making this measurement, the location of the end points, that is, the points at which the cusps and the aperture image just touch, proves to be highly sensitive.

To examine the parallel sizing portion of the die, the die is tilted slightly; the almost circular annulus in the image reproduced in Fig. 5 is due to the parallel portion of the die and, as before, any scoring may be recognised by radial lines across the annulus. In Fig. 5, and touching the image of the die aperture (which is slightly elliptical because of the tilt of the die), is a small egg-shaped image; this is produced by the back relief of the die beyond the forming portion of the die.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

SHIPBUILDING AND ENGINEERING AT GREENOCK.—Mr. J. Y. Inness, convener of the shipbuilding and engineering section of Greenock Chamber of Commerce, in his annual report for 1952, which was submitted this week at the annual meeting of the members, states that if steel supplies had been favourable during the year, the output from shipyards and engineering works in the Greenock area would have reached an unprecedented total. The vessels launched aggregated 172,194 tons, which total was 20,567 tons higher than in 1951. Marine engines totalled 83,360 i.h.p., which was 44,142 i.h.p. below the 1951 figure. The reduction was accounted for mainly by the continued slow deliveries of materials.

CLYDE LAUNCHING STATISTICS.—In April, Clyde shipbuilding firms launched 11 ships, totalling 88,030 tons gross, bringing their output for the four months of the year to 22 ships aggregating 131,163 tons gross. This compares with 18 ships and 123,870 gross tons in the corresponding period of 1952. The April total was the largest recorded for any month in the post-war period.

RECORD ROLLING-MILL PRODUCTION.—The cogging mill at Dalzell Steel Works, Motherwell, owned by Colvilles Ltd., set up a record output of 7,052 tons in the week ending May 2. The mill produces steel semies for finish rolling in the 27-in. and 36-in. mills.

TWO OLD SHIPS.—The oil tanker British Architect (7,388 tons), owned by the British Tanker Co., Ltd., arrived in the Clyde on May 6, from Aden, to be broken up at Port Glasgow. The vessel was built by the Blythswood Shipbuilding Co., Ltd., Glasgow, in 1922. The Wick Harbour Trust have given permission to Mr. Calder Sutherland, a diver, employed by the Trust, to use their diving gear for salvage work on a wreck on the north side of Wick Bay. This is a private venture, and will be carried on outside ordinary working hours. The ship was wrecked during the war.

CLEVELAND AND THE NORTHERN COUNTIES.

BOLDON AIRPORT, SUNDERLAND.—The North-East Airport Joint Committee have appointed a deputation to interview the authorities in London regarding the possibility of proceeding with the 5,000,000*l.* scheme for an airport at Boldon, near Sunderland. The Government decided shortly after the war, that Boldon was the most suitable location for an airport to serve the North-East, but so far, permission has not been given to proceed with the work.

RENEWAL OF TANKS IN OIL TANKER.—The 8,200-tons oil tanker British Bombardier has arrived at the Middle Docks and Engineering Co., Ltd., South Shields, for the renewal of her tanks. The vessel called at the yard last year to have measurements taken for the work, and later returned to service. In the meantime, the new tanks have been prefabricated by the South Shields firm and are now ready for installation. The Middle Docks Co. have completed a 40-ft. extension to their No. 3 dock which is accommodating the British Bombardier. The work was completed ahead of schedule by Brims & Co., Ltd., Newcastle, who have carried out a number of dock and shipyard development schemes.

GYPSIES GREEN COAL SIDINGS.—South Shields Town Council have decided to take no action which would hinder the National Coal Board's plans for new sidings at Gypsies Green, South Shields. The proposal has been objected to by residents living nearby. The Coal Board intends using electric locomotives on the sidings and to spray water on the coal to prevent a nuisance from smoke and dust, as far as possible.

SHIP-BREAKING ACTIVITIES AT BLYTH.—With the arrival of the 9,000 tons steamer, Mantola, the Blyth ship-breaking firm of Hughes, Bolckow & Co., Ltd., now have five ships alongside their quay for dismantling. The others are the Assimina, Begum, Rosalba, and Olcades. This is thought to be the first time so many vessels have been at the yard simultaneously for breaking-up. The work will last for about six months.

SHIPBUILDING AT BERWICK.—Reports have been current that the Berwick, Northumberland, Shipyard of William Weatherhead and Sons which was reopened three years ago, is to close down. Mr. J. Weatherhead, commenting on the matter, has said that the yard would not be closed "just now." He added that the yard still had a number of orders on hand. Last year, Messrs. Weatherhead closed their small boat-building yard at Spittal, Northumberland.

THE LATE COLONEL C. H. LUMLEY, O.B.E.—We note with regret the death of Colonel Charles Hope Lumley, O.B.E., which occurred in a nursing home at Brighton on April 29. Colonel Lumley, who was 64 years of age, was appointed director of home sales (industrial) of Sigmund Pumps Ltd., Team Valley, Gateshead-on-Tyne, 11, in June, 1951. He served in the South Lancashire Regiment and afterwards entered the Ministry of Munitions during the war of 1914-18, subsequently receiving the O.B.E. for his services. In June, 1940, he was appointed Regional Controller of the North of England for the Ministry of Supply and when this work came to an end in August, 1945, Colonel Lumley went to Germany to take up the post of economic adviser, Hamburg, under the Foreign Office. Subsequently he was made deputy commissioner of Hamburg under the British Control Commission. Colonel Lumley was deeply interested in the welfare and future of the North-Eastern trading estates.

LANCASHIRE AND SOUTH YORKSHIRE.

MANUFACTURE OF MOTOR-CAR COMPONENTS.—The settlement of the Austin Motor Company's dispute has lifted some of the depression which, latterly, has overhung the steel and iron firms making motor-car components. A good deal of short-time working has been caused in some Sheffield and Rotherham steelworks making springs and other accessories. Derbyshire, Nottinghamshire and Lincolnshire iron foundries which have also suffered are hopeful that a change for the better will now take place.

SHEFFIELD AND THE SOUTH AMERICAN TRADE.—Industrialists who have recently visited South-American countries in search of more business have been disappointed that, in specific cases, there seemed to be no provision in trade agreements for the import of Sheffield steels or tools. Mr. Frederick Franks, managing director of the Furnival Steel Co., Ltd., Sheffield, states that in Brazil, Uruguay and the Argentine he saw stocks of steels of various kinds, including twist drills, hacksaws and similar tools, but none was British. Among the steel goods were stainless-steel sheets from the United States and Sweden.

UNSUITABLE COKE FOR FORGINGS.—Some hand-forgers in the Sheffield cutlery industry have given up their skilled work because the East Midlands Gas Board has ceased to supply the small washed coke which is essential to them as a fuel. The Board states that, even at 5*l.* a ton, the labour involved in washing it makes the sale of the coke an uneconomic proposition. The forgers have been directed to purchase hard coke but they state that this fuel is not satisfactory and add that four-fifths of the unwashed coke is unusable.

THE MIDLANDS.

DEMONSTRATION AIRLIFT FOR MOTORISTS.—On Wednesday, May 6, the Automobile Association organised an experimental flight, conveying a number of cars and motor-cycles from Elmdon Airport, Birmingham, to Le Touquet and back, in a Bristol Superfreighter aircraft. The object was to demonstrate that it should be possible in the near future for cars and motor-cycles to be transported by air over relatively long distances at economic rates, thereby saving nearly a full day's travelling time.

FOUNDRY VISITS OF WORSHIPFUL COMPANY OF FOUNDERS.—The Master, Mr. Kenneth H. Adams, and the Upper Warden, the Rev. R. B. R. Walker, of the Worshipful Company of Founders, supported by more than 20 members of the Livery, participated in the third annual foundry visit covering the period April 20 to 22. The party gathered at Lichfield on the evening of April 20 and, on the morning of April 21, a visit was paid to the Austin Motor Co. Ltd., Longbridge. In the ironfoundries a wide range of automobile castings, particularly cylinder blocks and cylinder heads, were seen in producton by mechanised methods. In the afternoon the party proceeded to Bordesley Hall, the headquarters of the British Cast Iron Research Association, and inspected the laboratories, offices and work in progress. On the morning of April 22, the party saw the Coneygre Foundry Ltd., of Tipton, and witnessed the whole of the processes involved in the preparation of automobile cylinder blocks, heads and other cylinder castings in high-quality grey iron.

VISIT TO CAMBRIDGE INSTRUMENT COMPANY.—On April 29 and 30, the Cambridge Instrument Co., Ltd., restored a popular pre-war custom by opening their works, in Chesterton-road, Cambridge, to those members of the University concerned with the teaching and study of scientific subjects. All the workshops and research departments were open for inspection and displays and demonstrations were given of many of the company's products. Of particular interest was a large optical bench, which has a base of approximately 30 ft.; an electro-cardioscope for continuously monitoring the condition of the human heart during actual cardiac operations; quick-acting electronic recorders for various applications; high-precision measuring machines of strictly-kinetic design; and microtomes for cutting sections of biological material down to a thinness of 0·0007 mm. for electron-microscopic examinations. During the two days over 800 visitors were received.

COAL BORING AT WOLVERHAMPTON.—Wolverhampton Town Council have reversed their decision, reached 19 months ago, to refuse permission for the sinking of a borehole on a playing field at Penn, one of the south-western suburbs of the town. The National Coal Board proposed to put down the borehole to prove an extension of the coal seam at present being worked by the nearby Baggeridge Colliery. It will now be possible to proceed with the borehole, which is, at present, solely for exploratory purposes. No suggestion has been made that mining is about to begin in the area. The Town Council, in agreeing to the borehole proposal, have reserved their rights to oppose the mining of coal under Wolverhampton, should the question arise in the future.

LIGHTHOUSE FOR CORREGIDOR.—The Smethwick, Staffs., firm of Chance Brothers, Ltd., have completed the equipment for the new lighthouse at Corregidor, Philippines, which is to replace the one destroyed during the recent war. The new light, which is electric, is equipped with Diesel generators having automatic change-over equipment to ensure that, should one generator fail the other will come into operation automatically. Light-keepers from the Philippines have been trained by Chance Brothers, Ltd., ready to operate the light as soon as it is installed.

LEAD MINING IN SHROPSHIRE.—Work is in progress at several places in the district of Stiperstones, near the Shropshire-Montgomeryshire border, to investigate the prospects of re-opening some of the old lead mines there. The area is an ancient lead producer—there are records of mining in Roman times—and until about 30 years ago, the mines supported a population of about 2,000. The last mine to work there closed down in 1925, and although there have been suggestions from time to time that operations should be re-started, nothing has been done until now. The work being carried on at present includes the clearing of a shaft in the village of Hope, the sinking of a new shaft near old workings at Pennerley, and some horizontal drifting.

SOUTH-WEST ENGLAND AND SOUTH WALES.

NEWPORT COAL SHIPMENTS.—Monday, May 4, was a good day for coal shipments at Newport Docks. A total of 11,800 tons of cargo and 29 tons of bunkers was loaded for foreign and coastwise destinations. This was the best single day's performance since October, 1950. The port's shipments in the week ended May 3 amounted to 34,374 tons, which was the best week since November, 1952.

SWANSEA OIL TRADE.—The oil trade of Swansea docks continues to expand. In the first sixteen weeks of the present year, imports totalled 1,409,309 tons, against 1,310,999 tons in the corresponding period of 1952. Similar figures for exports were 1,107,073 tons and 1,105,439 tons.

SOUTH WALES PORTS TRADE STATISTICS.—The trade of the South Wales ports in the period from January 1 to April 19 this year, totalled 6,568,972 tons, compared with 6,738,100 tons in the corresponding period of 1952. Imports were up from 2,801,185 tons to 2,980,173 tons, but exports declined from 3,936,915 tons to 3,588,599 tons.

WEST WALES TIN-PLATE POSITION.—The tin-plate position in West Wales continues to cause some anxiety. Following the decision of Richard Thomas and Baldwins Ltd. to close six of their works, the Llanelly local authorities have approved a memorandum prepared by the council officials on the gravity of the position. The memorandum is to be forwarded to the South Wales Development Committee and the Welsh Board for Industry. A deputation has also been appointed to meet Mr. James Griffiths, M.P.

NOTICES OF MEETINGS.

It is requested that particulars for insertion in this column shall reach the Editor not later than Monday morning in the week preceding the date of the meeting.

INSTITUTION OF ELECTRICAL ENGINEERS.—*London Students' Section:* Monday, May 18, 7 p.m., Savoy-place, Victoria-embankment, W.C.2. Annual General Meeting and Film Display. *Measurements Section:* Tuesday, May 19, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. Section Annual Lecture on "Measurement with the Flying-Spot Microscope," by Professor J. Z. Young, F.R.S. (Postponed from May 5.) *Education Discussion Circle:* Tuesday, May 19, 6 p.m., Savoy-place, Victoria-embankment, W.C.2. Questions Night. *Supply Section:* Wednesday, May 20, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. Lecture on "The Utilisation of Solar Energy," by Dr. E. C. Bullard, F.R.S.

INCORPORATED PLANT ENGINEERS.—*Liverpool Branch:* Monday, May 18, 7.15 p.m., Radiant House, Bold-street, Liverpool. "Report on Visit of Plant Maintenance Team to the United States," by Mr. Colin Troup. *Hertfordshire Discussion Group:* Tuesday, May 19, 7.30 p.m., Peahen Hotel, St. Albans. "Sound Control in Industry," by Mr. W. A. Hines. *Kent Branch:* Wednesday, May 20, 7 p.m., Bull Hotel, Rochester. Open Discussion Meeting. *South Yorkshire Branch:* Thursday, May 28, 7.30 p.m., Grand Hotel, Sheffield. Discussion on "New Developments in the Coal-Mining Industry." *Birmingham Branch:* Friday, May 29, 7.30 p.m., Imperial Hotel, Birmingham. "Dust Control," by Mr. R. J. Pitt.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, May 19, 5.30 p.m., Great George-street, Westminster, S.W.1. James Forrest Lecture on "The Impact of Statistics on Civil Engineering," by Professor H. Levy.

ROYAL STATISTICAL SOCIETY.—*Study Section:* Tuesday, May 19, 6 p.m., Lighting Service Bureau, 2, Savoy-hill, W.C.2. "Sample Surveys and Their Use for Administrative Purposes," by Mr. L. Moss. *Main Meeting:* Wednesday, May 27, 5.15 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, Gower-street, W.C.1. "An Experimental Study of Quota Sampling," by Mr. C. A. Moser and Mr. A. Stuart.

INSTITUTION OF PRODUCTION ENGINEERS.—*Sheffield Graduate Section:* Tuesday, May 19, 6.30 p.m., Royal Victoria Station Hotel, Sheffield. "The Application of Tungsten-Carbide Tooling," by Mr. A. Brooke. *Shrewsbury Section:* Wednesday, May 27, 7.30 p.m., Shrewsbury Technical College, Shrewsbury. "Electronics as an Aid to Productivity," by Mr. R. McKennell.

ROYAL METEOROLOGICAL SOCIETY.—Wednesday, May 20, 5 p.m., 49, Cromwell-road, South Kensington, S.W.7. (i) "Annual Recurrences in Edinburgh Temperature," by Mr. D. H. McIntosh; (ii) "Climatic Fluctuations in the Greenland and Norwegian Seas," by Mr. P. R. Brown; and (iii) "The Mean Temperature of Central England, 1698 to 1952," by Mr. G. Manley.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*Manchester Branch:* Wednesday, May 20, 7.30 p.m., Engineers' Club, Albert-square, Manchester. "Principles of Organisation," by Mr. D. V. Burling. *South-West London Branch:* Wednesday, May 20, 8.15 p.m., Guild House, 32, Worple-road, Wimbledon, S.W.19. "Electrical Contracting," by Mr. G. Kitchener.

ROYAL AERONAUTICAL SOCIETY and PHYSICAL SOCIETY (*Acoustics Group*).—Thursday, May 21, 10 a.m., 2.30 p.m. and 4.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. Joint All-Day Meeting on "Aeronautical Acoustics: In Particular Jet Noise." For programme, see page 580, *ante*.

ROSS INSTITUTE OF TROPICAL HYGIENE.—Thursday, May 21, 2.15 p.m., Rubber Growers' Association, 19, Fenchurch-street, E.C.3. Various short papers, on health subjects and industrial relations, for discussion.

INSTITUTION OF STRUCTURAL ENGINEERS.—Thursday, May 21, 5.30 p.m., Royal Technical College, George-street, Glasgow. Annual General Meeting of the Institution. "Engineering Aspects of the New Atomic Research Extension, University of Glasgow," by Mr. D. M. Hamilton and Mr. J. Hardie Glover.

ROYAL INSTITUTION.—Friday, May 22, 9 p.m., 21, Albemarle-street, W.1. "The Discovery of X-Ray Diffraction by Crystals," by Professor Sir Lawrence Bragg, F.R.S.

SOCIETY OF INSTRUMENT TECHNOLOGY.—Tuesday, May 26, Manson House, 26, Portland-place, W.1. 6 p.m., Annual General Meeting. 7 p.m., "The Instrumentation of Pilot and Experimental Scale Plant," by Mr. W. A. Goldstein.

ROYAL MICROSCOPICAL SOCIETY.—Wednesday, May 27, 5.30 p.m., Tavistock House South, Tavistock-square, W.C.1. (i) "High-Speed Automatic Counting of Microscopic Particles—The Flying-Spot Microscope," by Mr. D. Causley; and (ii) Demonstration of the Permanent-Magnet Electron Microscope, by Mr. R. W. Horne.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Birmingham Branch:* Wednesday, May 27, 7.15 p.m., James Watt Memorial Institute, Great Charles-street, Birmingham. "Some Practical Aspects of Aluminium Founding," by Mr. E. Raybould.

INSTITUTION OF MINING AND METALLURGY.—Thursday, May 28, Geological Society's Apartments, Burlington House, Piccadilly, W.1. 4 p.m., Annual General Meeting (open to corporate and non-corporate members only). 5.15 p.m., Presidential Address, by Professor J. A. S. Ritson.

EXHIBITION OF HISTORIC BOOKS ON MACHINES.

DURING the period May 1 to August 30, an interesting exhibition of historic books on machines is on view at the Science Museum, South Kensington, London, S.W.7. The books selected depict the development of machines from classical times up to the industrial revolution in the Eighteenth Century, and most contain illustrations of great historical interest. The high standard of presentation and draughtsmanship, particularly noticeable in some of the earlier volumes, compares more than favourably with present-day standards of book production.

Among many fascinating examples are the first printed book on engineering, by Valturius, printed in 1472; the volume on view, however, was published in 1534. Two books by Heron of Alexandria, who lived some time between the First Century before and the Third Century after Christ, published in Italy in 1575 and 1572, respectively, describe, among other things, a fire engine consisting of two cylinders with pistons coupled by connecting rods to the end of a beam, the earliest reaction turbine, and a large drilling machine for making a hole through a wall, for military purposes. A beautifully-illustrated book by the Fifteenth Century scientist Agricola, describes multiple-stage reciprocating mine pumps, driven by water-wheels, and horse-driven pumps with rack-gears and chains, arranged in series to drain mines, with a total lift of over 200 ft.

An example of particular interest, by Fontana, published in 1590, describes the transfer of the 83-ft. high solid granite obelisk from the back to the front of St. Peter's, Rome, by 900 men and 74 horses, using 40 capstans operating in conjunction with pulley-and-tackle machines. A volume by d'Acres, published in 1659 and 1660, is the earliest work by an English writer devoted entirely to apparatus for raising water. Experiments on the effect of altitude on atmospheric pressure are described in a book by Pascal, published in 1648. The first set of weekly journals published by the London Mechanics' Institution, opened in 1823, is on view. Other examples are concerned with windmills, some of which are particularly well illustrated; many descriptions of water pumps; a calculating machine; observations of bird flight; the construction of clocks; textile machinery; railway history; and Michael Faraday's researches.

Many other interesting works are to be found in the exhibition. Details of the exhibits are given in the catalogue, *Historic Books on Machines*, by Dr. C. St. C. B. Davidson, M.Sc., obtainable at the Science Museum, or from H.M. Stationery Office, Kingsway, London, W.C.2, price 1*s.* 6*d.* net.

TUNNEL-TYPE HULLS.—In a paper on this subject recently read before the Institution of Engineers and Shipbuilders in Scotland, by Mr. A. R. Mitchell, M.B.E., M.C., who is the naval architect to Yarrow & Co., Ltd., Glasgow, outlined the advances made in the design of the tunnel type of vessel from the time of the simple invention of the tunnel by John Buchanan a century ago, and the patenting of the hinged flap by Sir Alfred Yarrow 50 years ago, to the present day. A large variety of shallow-draft vessels fitted with tunnels and now operating successfully in inland waterways throughout the world were illustrated and the results of tank tests, trials, towing, steering and varying forms of tunnels with and without flaps were given. The author hoped that, although only a small percentage of the shipbuilding industry was engaged on the design and construction of tunnel vessels, his paper would be found interesting, and that it had proved at least informative to those countries where, at the present time, inland water transport was engaging so much attention.

PERSONAL.

SIR DONALD ST. CLAIR GAINER, G.B.E., K.C.M.G., has been elected chairman of Council of the International Road Federation, 18, South-street, London, W.1.

MR. R. D. HAMER, B.Sc., vice-president and director of Aluminium Laboratories Ltd., has been elected President of the Aluminium Development Association, 33, Grosvenor-street, London, W.1, for the year 1953-54. The new vice-president of the Association is MR. H. G. HERRINGTON. MR. G. W. LACEY has been re-elected chairman of the executive committee of the Association.

MR. K. H. PLATT, M.B.E., B.Sc., M.I.Mech.E., has been appointed assistant secretary of the Institution of Mechanical Engineers as from May 1.

MR. C. P. STORR, M.A., M.I.Mech.E., M.I.E.E., has been appointed power systems engineer of the Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17. MR. J. I. LAW-BROOKS has relinquished the duties of manager of the firm's London district office, but will carry out certain special duties and remain available for consultation until December 31, 1953. MR. E. MEAD, B.Sc. (Eng.) Lond., M.I.E.E., has been appointed manager, London office, as from May 1.

MR. W. B. JOHNSTONE, O.B.E., has been elected chairman of the Dry Dock Owners and Repairers Central Council. MR. A. C. WADDY, O.B.E., has been elected senior vice-chairman and ENG. CAPT. G. VILLAR, R.N. (ret.), junior vice-chairman.

MR. W. R. BLACK has been elected President of the Society of Motor Manufacturers and Traders, 148, Piccadilly, London, W.1, in succession to MR. HENRY SPURRIER, M.I.Mech.E., M.I.P.E., M.Inst.T., who now becomes deputy president. MAJOR-GENERAL J. S. CRAWFORD, C.B., C.B.E., M.I.Mech.E., M.I.Mar.E., has has been appointed treasurer of the Society on the election of Mr. Black to the presidency.

MR. ARTHUR WOOD, who is managing director of C. E. Johansson Ltd., Southfields-road, Dunstable, Beds., has been appointed to the board of Henry Meadows Ltd., Fallings Park, Wolverhampton, and H. Widdop & Co. Ltd., Keighley, Yorkshire.

MR. S. D. CANVIN, B.Sc.(Eng.), M.I.C.E., M.Inst.W.E., chief engineer and general manager of the Glasgow Corporation Water Department, has been elected chairman of the Glasgow and West of Scotland Association of the Institution of Civil Engineers.

MR. R. W. RUTHERFORD has been appointed deputy managing director of the Power-Gas Corporation Ltd., and Ashmore, Benson, Pease & Co. Ltd., Stockton-on-Tees.

MR. J. T. SHARPLES, B.Sc.Tech., A.M.I.E.E., formerly engineer-in-charge, heating element department, the Metropolitan-Vickers Electrical Co. Ltd., is now district engineer and manager (Northern Counties) with Barlow-Whitney Ltd., Coombe-road, Neasden-lane, London, N.W.10. Mr. Sharples will operate from 32, Deansgate, Manchester, 3. (Telephone: Blackfriars 3851.)

MR. B. N. H. THORNELY, B.A., M.I.Mech.E., has been appointed to the board of directors of the Northern Aluminium Co. Ltd., Banbury, Oxfordshire.

MR. W. C. LYLE, works manager, Cassel Works, Imperial Chemical Industries Ltd., Billingham-on-Tees, has been appointed deputy operations manager, General Chemicals Division of the I.C.I., at Liverpool. His successor as manager, Cassel Works, is DR. R. N. KERR.

MR. H. BOYD BROWN, B.Sc. (Eng.), A.M.I.E.E., assistant to the chairman of Associated Electrical Industries Ltd., Crown House, Aldwych, London, W.C.2, has been appointed managing director of First Electric Corporation of South Africa, as from May 1. His successor as assistant to the chaiman of Associated Electrical Industries Ltd., is MR. W. A. ANKERSON, B.Sc. (Eng.), A.M.I.E.E.

MR. G. S. MILNE, surveyor to Lloyd's Register of Shipping, Sunderland, has been appointed general manager of John Lewis and Sons, Ltd., shipbuilders, Aberdeen.

MR. W. B. MOTUM, a special director of Vickers Ltd., and chief accountant of Vickers Ltd., and Vickers-Armstrongs Ltd., retired on April 30. His successor as chief accountant of both companies is MR. M. G. SPRIGGS, M.A., A.C.A.

THE HYMATIC ENGINEERING CO. LTD., Redditch, Worcestershire, have appointed HENRY WAUGH & CO. LTD., Palmerston House, 51, Bishopsgate, London, E.C.2, their agents in Singapore, Malaya, Thailand, Sarawak, Labuan, Brunei and British North Borneo.

THE ENGLISH STEEL CORPORATION LTD., Sheffield, 9, have concluded an agreement with the GENERAL STEEL CASTINGS CORPORATION, Granite City, U.S.A., under which the English firm will produce, in quantity, special railway castings of a type which they have already been developing, such as one-piece bogies and locomotive frames. The trade name of these products is "Commonwealth."

EXHIBITS AT THE BRITISH INDUSTRIES FAIR.

(*For Description, see Page* 630.)

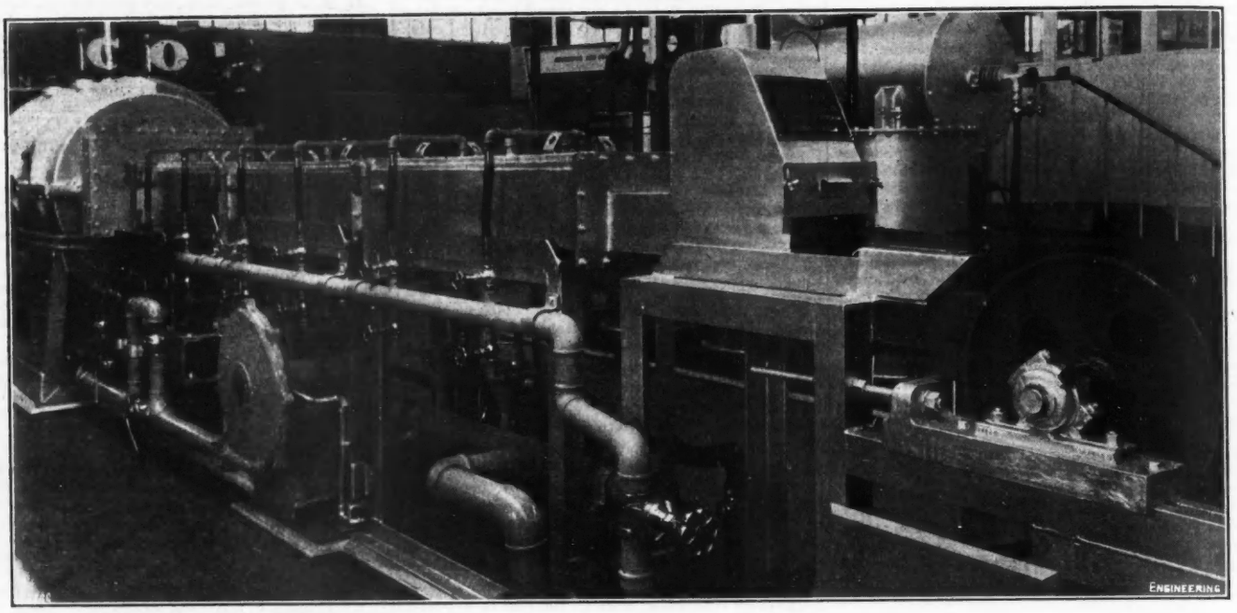


FIG. 46. CONTINUOUS BRAZING FURNACE; INCANDESCENT HEAT CO., LTD.

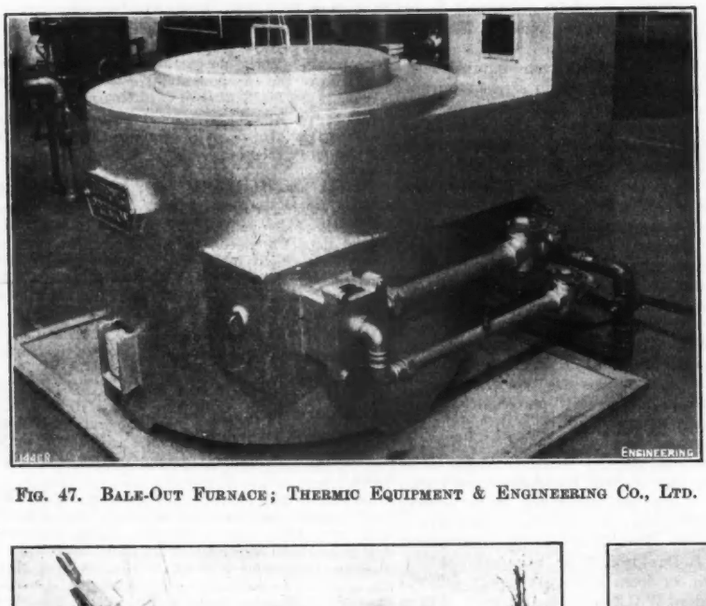


FIG. 47. BALE-OUT FURNACE; THERMIC EQUIPMENT & ENGINEERING CO., LTD.

FIG. 48. FORK-LIFT TRUCK WITH WEIGHING EQUIPMENT; I.T.D. LTD.

FIG. 49. CABLE-DRUM CARRIER AND LAYER; WHITLOCK BROS., LTD.

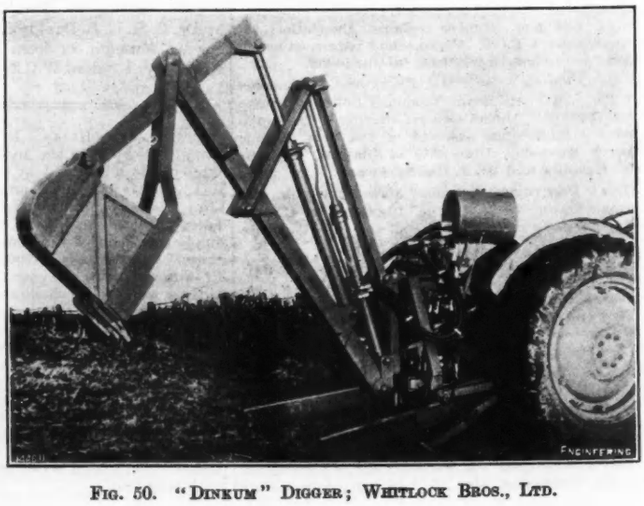


FIG. 50. "DINKUM" DIGGER; WHITLOCK BROS., LTD.

ENGINEERING

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

Registered at the General Post Office as a Newspaper.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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ENGINEERING, LESQUARE, LONDON.

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For Canada	£5 5 0

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ADVERTISEMENT RATES.

Terms for displayed advertisements can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 10*s.* for the first four lines or under, and 2*s.* 6*d.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 30*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Monday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received 16 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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PLATE.

Plate XIX.—ELECTRICALLY-DRIVEN 42½-IN. COGGING MILL.

ENGINEERING

FRIDAY, MAY 15, 1953.

VOL. 175. No. 4555.

A THOUGHT FOR THE FUTURE.

IN the Trueman Wood Lecture delivered to the Royal Society of Arts this week, Sir Richard Southwell, F.R.S., succeeded where a lesser man would have failed: though he dealt with a hackneyed subject—"Training for Science and Technology"—his words carried the authority of one who has made highly original contributions to science and technology, yet has shunned a narrow academic outlook. He set out to think about the problem of training as a whole, facing up to the unpleasant facts of the situation in this country, and reaching certain conclusions with which, as he remarked, some of his old colleagues would be displeased. "The task of the universities," he said, "is but one of many," and he proceeded to sketch the whole panorama.

Science and technology are relay races—races between schools and between colleges, between firms and between nations—and education largely determines the deftness with which the torches are handed on. The man responsible for training cannot know what will be required of the student in the next few decades; the student himself can only look for guidance; and the future employer, even if he could be identified, would despair at the idea of formulating his future needs. With so much uncertainty the subject is of perennial interest, and when the field of uncertainty is widened by wars, rearmament, shortage of trained men, slowness in applying the results of research, and an economic background which is a formidable challenge to statesmen and industrialists alike, the subject can properly be debated afresh for each generation and for each change in the circumstances. But only on one condition: that those who speak shall speak in relation to the whole problem.

For Sir Richard Southwell this attitude led to the conclusions, broadly expressed, that the structure of British technological education should be conditioned by the structure of British industry, and not copied slavishly from practice abroad, however excellent in its own environment; that university undergraduate courses should provide education in "science which is pursued with a view to application," not in science concerned directly with applications; that post-graduate training, on the other hand, should be related deliberately to actual applications, the courses being arranged in conjunction with industrial firms and research associations; that great harm will be done to the nation's industries if all the best brains go through the universities; and that something must be done, and done quickly, to ensure an adequate succession of science teachers. Expressed in these terms, the problem is a problem of relative values and factors; it is therefore amenable to the slow ripening, the development, rather than sudden change, which Sir Richard Southwell would like to see fostered.

Thus he condemned the proposal, which has officially been dropped, to build a great technological university on the lines of Delft or Zürich or M.I.T. Apart from the fact that such a project would be mere copying, unrelated to the traditions and needs of British industry, it does not overcome the difficulty of staffing which already besets existing educational establishments. Three years, he believes, is enough for an undergraduate in a university. In undergraduate courses, he considered, there should be as little differentiation as possible because it is only after some experience of industry that the best men discover their special aptitudes. It is more than likely that this applies to most engineers in the course of their careers. It would, indeed, be informative to take a census among a cross-section of engineers of all ages and branches of the profession to reveal the extent to which they are doing work for which they were originally trained. The questionnaire would require to be framed very carefully, but it should ask what type of work each man set out to do when he started his training; what work he was actually trained for; and what work he is, in fact, engaged on. The answers would doubtless point to some extraordinary instances of changing horses in mid-stream, but that would not necessarily condemn the educational system; rather would it show how large is the area of uncertainty and how right is the opinion that undergraduate training should be in basic principles.

In post-graduate work, however, Sir Richard advocates courses on actual applications, given near to works and other industrial establishments, where the latest "hardware" and processes can be studied and creative techniques can be taught by men who practise them. The instructors could not make long journeys; the students would have to come to them. Such courses (as contrasted with thesis work), which are offered to post-graduate engineers at one or two British universities, appear to have been outstandingly successful, but not wholly successful, as Sir Richard points out, since only a few industrialists have so far co-operated. Nevertheless, he agrees that those industrial leaders are right who urge that the "university product is not enough." The nation's reserves of intelligence must not all be canalised through the universities, since not all skills vital to the national economy are best acquired there. The structure of industry in this country has been built on a tradition of abundant craftsmanship, and provision must be made for continuing the line in the future. By proclaiming his opinions on scientific and technological training, Sir Richard will command wide agreement among engineers, even if he offends a few, and he may encourage many to reckon with the significance of Lord Rutherford's saying—which he quoted—"We get no money, so we *have* to think."

THE CASE FOR ELECTRICAL DEVELOPMENT.

THE proceedings of the fifth British Electrical Power Convention, which is to be held at Torquay early next month, are to be based on the subject of the increasing part electricity can, and should, play in the national economy. Three basic papers are to be presented: by Colonel B. H. Leeson on "Electricity and National Prosperity"; by Mr. E. R. Wilkinson on "Electricity and Industrial Production; and by Mr. S. F. Steward on "Electricity and Food Production." The last two papers are each to be supported by three supplementary communications, dealing with more detailed aspects of the main subject. In addition, Sir John Hacking is to deliver a presidential address, in which we have no doubt the problems of the electricity-supply industry as they exist to-day will be cogently reviewed. Those attending the Convention, to the number, it is expected, of over 2,000, will therefore be provided with plenty of matter for consideration, discussion and subsequent action.

Now, although the audiences at the meetings of the Convention will be adequately representative of the different branches of the electrical industry, they will have at least one qualification in common: a conviction that one way at least out of the troubles which at present beset British industry is to increase the amount of power at the disposal of the operative and that such a development will automatically imply a corresponding increase in the consumption of electricity. The authors of the papers will, therefore, be preaching to audiences who are in full agreement with their views and their position will thus be analogous to that of a clergyman who complains from the pulpit of the prevalent neglect of church-going. If, however, the desired development is to be brought about (and we must not be considered biased if we say that such a consummation is highly desirable) the attention of a wider public, both official and unofficial, must be attracted, since it will be mainly by making all classes of the community aware of the position that the necessary advances can be brought about within a reasonable time.

It was, we assume, a recognition of this fact that led those responsible for the organisation of the Convention to hold a reception last week, for the members of both the technical and lay press. At this gathering, what may be called a pre-audition of the contents of the three principal papers was given by their authors. The idea is to be commended, not the least because, for more than one reason, the electrical industry is not, generally speaking, viewed by the lay press with that favour which its efforts to stimulate the prosperity of the country deserve. This is in some ways natural, but because it is an attitude which also prevails in some other quarters, some of the principal obstacles which the industry is having to face may be mentioned.

Generally speaking, the electricity supply branch, upon which, of course, a large part of the manufacturing section inevitably depends for its livelihood, is suffering from the long memories of some journals which prevent certain defects of past policy, for not all of which the industry is responsible, from being forgotten. These defects include a shortage of generating plant caused by the short-sighted action of the Government, which is only now beginning to be relieved. The result of this shortage has been the enforcement of load shedding, which has on occasion provided excellent news items; but has, in addition, led to criticism and a sense of frustration the blame for which has not altogether justly been laid on the industry. Partly owing to official action and partly owing to the self-denial of the industry itself, it has not for some time been possible to counter this by propaganda of a kind which was so skilfully carried out by the Electrical Development Association between the wars. Even had more been done in this direction the results may not have been entirely satisfactory, owing to the difficulties of explaining the technicalities of the position to the layman. This is pre-eminently a case where deeds are mightier than words. For every reason, therefore, it is to be hoped that this is a phase which has passed, never to return, and that the electrical industry will now be freely allowed to state its case.

The press conference, to which we have referred, may perhaps be regarded as a first step in that direction; and those present should have been left in no doubt regarding the important part that electricity can, and must, play in securing the future prosperity of the country. Colonel Leeson, for instance, pointed out that while during the past 50 years coal and cotton have been the staples of our overseas trade, in future their place will be taken by engineering; and that even now the engineering and metal industries together represent over 50 per cent. of our visible exports. The electrical manufacturing industry, he added, was capable of making further contributions to our economic recovery. In order to do so, however, it not only required the support of other industries, particularly that of coal, but the removal of the handicaps which are at present imposed on power-station construction and the development of the home market, especially owing to insufficient capital being available.

In dealing with the same subject from another angle, Mr. Wilkinson argued that our task was not merely to bridge the present trade gap, but to repay the 6,000*l.* million of foreign indebtedness which had been incurred during and since the war. This task, he emphasised, would have to be undertaken in a world which was becoming increasingly competitive and one, too, in which the use of electricity in industry was increasing more rapidly elsewhere than in this country. Further, the real benefits of our social programmes could not be secured or maintained unless supported by an essential rise in productivity and the rate of that rise in turn depended on an increase in our use of mechanisation. Hence he advocated maximum re-equipment with minimum capital expenditure and supported this argument by pointing out that in seven representative countries of Western Europe capital investment from 1947 to 1950 averaged about 23 per cent. of the national income, as against only 14 per cent. in Great Britain. In those countries, too, electricity supply was absorbing a greater share of the industrial capital than we were. Finally, Mr. Steward linked up the theme of Great Britain's dependence on electricity as a means of attaining prosperity with the paramount need for increased food production. He emphasised the progress that had been made in rural electrification during the past five years and said that farms were now being connected at the rate of nearly 200 a week. This movement, he argued, must be continued. As regards the future, every means must be found to reduce the capital cost of rural electrification by vigorous sales promotion and if, for reasons of food production, it was necessary to take an electricity supply into areas so remote as to be permanently uneconomic some form of subsidy might have to be considered.

The technical press, among which we include periodicals concerned mainly with economics and finance, will appreciate the soundness of the arguments we have outlined and will, it is to be hoped, bring them to the notice of their specialised readers. As regards what may be called the lay press, especially those journals which cater for what Mr. T. Driberg has called the "light programme" type of mind, we are not so optimistic. Attendance at many conferences leads us to the opinion that the representatives of such journals do not fully appreciate the problems involved and tend either to ignore the matter altogether or to deal solely with some irrelevant detail. Electricity supply, in spite of its importance, is, it may be admitted, lacking in human appeal and of little news value until some crisis arises. Even then, the assessment of the various factors involved is too often influenced by secondary considerations. In fact, the attempt to state the electrical case is surrounded with so many difficulties that while wishing those concerned success in their campaign it is necessary to point out that they are tilling very stony ground.

NOTES.

STEEL AND COPPER CONTROL ENDED.

ANSWERING a question on steel supply and demand in the House of Commons on May 5, the Minister of Supply, Mr. Duncan Sandys, said that it was expected that home production of steel in 1953 would be about 17½ million ingot tons, or about 1·3 million tons greater than in 1952. In the light of this improved position, the Government had reviewed the present controls over distribution and, subject to the continuance of the voluntary scheme for the distribution of steel plate, announced on April 20 (see page 531, *ante*) they were satisfied that it was no longer necessary for iron and steel to be rationed. The Government, accordingly, had decided that, with the exception of tin-plate, the statutory control of the distribution of iron and steel should be brought to an end. The necessary Orders would be issued so as to take effect as from May 6. In a further comment on the position, Mr. Sandys stated that there were bound to be shortages of particular types of steel even in normal times. These shortages and difficulties could only be dealt with by detailed administrative arrangements; the maintenance of a general global steel allocation would not be of any assistance in overcoming special difficulties. In estimating the demand, the Government had assumed an increase of at least 6 per cent. in the consumption of steel by industry this year. In view of the ending of steel rationing, the statement made on copper by the Minister of Materials, in the House of Commons on the previous day, May 4, is of particular interest. This was to the effect that, after reviewing the situation in all its aspects, the Government had decided that private trading in copper should be restored at the earliest possible date. The necessary notice was being given to the Commonwealth producers and, from August 5, the private import and sale of copper could be permitted and the Copper Distribution Orders would be revoked. The London Metal Exchange, it was understood, would re-open for dealings in copper on the same day. An Order was being made with effect from May 5 authorising private contracts for the delivery of metal after the end of public trading.

FOUR TYPES OF LOCOMOTIVES.

Members of the Institution of Locomotive Engineers visited, on May 6, the works of the Vulcan Foundry, Limited, Newton-le-Willows, Cheshire, where four widely-differing types of locomotives, all of which are in process of being manufactured in the one works, were on display. The most impressive exhibit was an oil-fired 2-10-2 type locomotive, of which many are on order for the Iranian State Railways, of 4 ft. 8½ in. gauge. This type of locomotive is designed to deal with 592-ton trains on a 1·5 per cent. grade, where curves of 722-ft. radius occur, and, together with its tender, weighs 176 tons in full working order. The boiler operates at 199 lb. per square inch, and the tractive effort is 49,200 lb. at 85 per cent. boiler pressure. Another imposing exhibit was the 3,600-h.p., 3,000-volt direct-current main-line locomotive, with a designed maximum speed of 68·3 miles an hour, for the Spanish National Railways, of 5 ft. 6 in. gauge. This locomotive is being manufactured in collaboration with the English Electric Company, who are supplying the motors and electrical equipment. With a weight of 116 tons, the maximum tractive effort is 70,000 lb., and the continuous effort is 30,500 lb. The third exhibit

was a 1,500-h.p. Diesel-electric locomotive for the Queensland Government Railways, of 3 ft. 6 in. gauge, weighing 88 tons in working order. Features of this locomotive are the fabricated frame, with its centre portion completely plated over to serve both as a fuel tank and a base for the engine and generator, and also the out-rigging of the bogie spring anchorages. The fourth exhibit was an 0-6-0 type 204-h.p. Diesel-mechanical locomotive for Tasmania, built in conjunction with the Drewry Car Company. This locomotive is provided with a Gardner 8-cylinder engine coupled to a Wilson-Drewry five-speed box through a Vulcan-Sinclair fluid coupling.

ALTITUDE RECORD BY "OLYMPUS-CANBERRA" AIRCRAFT.

On Monday, May 4, an English-Electric Canberra aircraft, owned by the Ministry of Supply, and used by the Bristol Aeroplane Company, Limited, as a flying test bed for Olympus jet engines, attained an altitude of 63,668 ft. during a flight observed by officials of the Royal Aero Club and the Fédération Aéronautique Internationale. Subject to official confirmation by the latter body, this constitutes a new international altitude record for aeroplanes. The previous record, 59,446 ft., attained in 1948, was held by Mr. John Cunningham, D.S.O., D.F.C., in a modified de Havilland Vampire aircraft fitted with a Ghost engine. Apart from the Olympus engines, the record-breaking Canberra aircraft, which was piloted by the Bristol company's assistant chief test pilot, Mr. Walter Gibb, D.S.O., D.F.C., was a standard machine. Owing to the wing-span structure, the jet pipe diameter of the Olympus engines fitted in the Canberra has had to be restricted, and consequently full power cannot be used. The Olympus engine has two independent compressors in series, each of which is driven by a separate turbine. This form of design, it is claimed, reduces the tendency to surge, is flexible in operation, and renders possible the use of a higher compression ratio. The static sea-level thrust has been officially quoted as 9,750 lb., but it is believed that the engine has now been developed to give a greater thrust. The Olympus engine is on order for use in the Avro Vulcan delta-wing bomber aeroplane. It is also the subject of a licence agreement between the Bristol Aeroplane Company and the Curtiss-Wright Corporation in the United States.

GAUGE AND TOOL MAKERS' ASSOCIATION.

On Thursday, May 7, the Gauge and Tool Makers' Association held their quarterly luncheon at the Savoy Hotel, London. In the chair was Mr. F. W. Halliwell, M.I.Mech.E., M.I.Prod.E., President of the Association, who introduced the guest of honour, the Hon. Lincoln Gordon, the United States Minister for Economic Affairs in London and Minister-in-charge of the Mutual Security Agency's Special Mission to the United Kingdom. In his opening remarks the President said that but for Drake, Raleigh and others of the first Elizabethan Era there might be no United States to-day and certainly not an English-speaking one. He thought, therefore, that it was natural that the two nations should work together for Anglo-American unity. Mr. Gordon said that his Agency was probably a successor to the Economic Co-operation Administration; its purpose was to help in maintaining security on a basis of freedom and to work towards an effective economic relationship between the two countries and a rapid strengthening and intensive increase of productivity in British industry. He mentioned the American off-shore purchases, as they are termed, saying that last year, for Europe as a whole, 700 million dollars' worth (220*l.* million) were placed. This year the figure was to be between 1,250 and 1,500 million dollars' worth. The work of the contracts was spread over a period into 1956 or 1957 in some cases, and the total was some 3½ billion dollars' worth compared with the annual Western European production of 4 billion dollars a year, of which well over half was in the United Kingdom. That was in terms of sheer volume. Apart from its absolute volume he thought it was important in two other respects because it was somewhere halfway between aid—which was simple aid—and trade which was normal trade. He also said that his department would make every effort to help and solve the problems on a mutual basis. The toast of the guests was proposed by Mr. A. L. Dennison, M.I.Prod.E., the chairman of the Association, and Sir James Helmore, K.G.M.G., Permanent Secretary, Ministry of Supply, replied.

ATOMIC ENERGY ESTABLISHMENTS.

Some interesting information regarding the work carried on at the different atomic energy establishments in the United Kingdom was given by the Minister of Supply (the Rt. Hon. Duncan Sandys, M.P.) in reply to a question in the House of Commons on Monday, May 4. He said that these establishments were engaged on atomic research, development and production for both military and civil purposes. That at Harwell in Berkshire was responsible for fundamental research into nuclear physics and atomic energy, and provided basic scientific information to the other establishments. The radio-chemical centre at Amersham, in Buckinghamshire, was concerned with preparing radio-active substances, such as radium, radon and radioactive isotopes, and these were used for medical, scientific and industrial purposes. The production of fissile materials was directed from headquarters at Risley, near Warrington, where the design and planning offices were situated. There were factories at Springfield, near Preston, where pure uranium was produced from uranium concentrates; at Windscale, in Cumberland, where plutonium was produced from uranium in atomic piles; and at Capenhurst, in Cheshire, where there was a gaseous diffusion plant for separating the uranium isotope, U 235, from the more abundant isotope, U 238. This provided a fissile material which could be used as an alternative to plutonium. Research work on atomic weapons was being carried on at Aldermaston, in Berkshire, and at its substations at Woolwich and Fort Halstead.

SYMPOSIUM ON ROLLING MILL BEARINGS.

A dinner held at the Savoy Hotel, London, W.C.2, on Friday, May 1, marked the close of the Rolling Mill Symposium held by British Timken Limited, Cheston-road, Aston, Birmingham, 7, during that week. The object of the symposium was to provide those steelworks on the Continent which use Timken bearings in rolling mills and other plant with information about the application and handling of these bearings and to provide an opportunity for discussion and an interchange of ideas. The week opened on Monday, April 27, with a paper on "The Application of Taper Roller Bearings to Rolling Mill Roll Necks and Steel Works Plant," presented by Mr. W. P. Snedden, A.R.T.C., at the Birmingham factory, and a tour of the factory in the afternoon. On Tuesday, the Northampton factory was visited and a paper on "Handling and Maintenance of Tapered Roller Bearings in Rolling Mills" was read. On Wednesday, the group toured the B.I.F. at Castle Bromwich, Birmingham. On Thursday, there was a paper on "Extreme Pressure Greases for Roll Neck Bearings and the Testing of Film Strength," followed by a visit to Richard Thomas and Baldwins, Limited, to see the Ebbw Vale Works, and on Friday, before returning to London, there was a tour of the Steel Company of Wales, Limited, Trostre. Speaking at the dinner, Mr. F. J. Pascoe, chairman and managing director of British Timken, Limited, said that people from ten different countries had taken part in the symposium and he hoped that they all felt that it had been worth-while. Discussing standardisation, he said there were many who thought that it was simply a job of selecting a few sizes and keeping to them, but the largest bearing his company had made weighed 3½ tons and the smallest one hundredth of an ounce, a difference of 12,500,000 times; where then should standardisation begin? His company, he said, had increased its manufacturing capacity considerably since the war and was planning to increase still further. Mr. M. Perin, Soc. des Tubes de Vincey, Vincey, France, replying for the guests, expressed his thanks to the company and said that he was certain they had all learned much from the visit and would be able to apply the knowledge and benefit by the contacts gained.

PRODUCTIVITY REPORT ON GAS.

During 1952, a productivity team representing the British gas industry visited the United States to survey the American gas industry. They studied industrial relations and training programmes, the carbonisation of coal and of heavy-oil residues, the use of tail gases from the distillation of petroleum and of liquid petroleum gases for augmenting gas supplies, the purification of gases used for town purposes, the distribution of gas (in particular high-pressure distribution and storage), the application of gas for domestic, commercial and industrial purposes, consumer service, and the treatment of peak loads and tariffs. The report of the team, issued on May 11, may be obtained from the British Productivity Council, 21, Tothill-street, London, S.W.1, price 8*s.* 6*d.* The team realised from the outset that the conditions under which the British and American gas industries operate are not comparable, since 93 per cent. (on a thermal basis) of the gas supplied by the American industry comes from their vast reserves of natural gas, and gas manufactured from coal, coke and oil amounts to about 5 per cent. of the total gas sales, whereas in the United Kingdom 99·7 per cent. of the total gas sold is manufactured. The team, nevertheless, found many ways in which American practice could advantageously be applied in the British industry. For instance, by adopting American methods of cathodic protection for underground distribution plant, its life could be extended, and an increasing use could be made of steel in place of cast iron, with a consequent reduction of some 50 per cent. in the use of raw material. The team also thought that the techniques evolved in America for long-distance transmission systems would be valuable with the further extension of gas grids in the United Kingdom, although, since the distances involved would be much shorter, high initial pressures such as are used in the United States—e.g., 800 lb. per square inch—were not envisaged. In laying main and service distribution systems, mechanical aids are much more widely used in America, and the team felt that some mechanical handling equipment might well be introduced for main and service laying in new towns, large housing estates, and for interlinking mains. On the production side, the team suggest that American methods for utilising natural gas might be applied to methane recovered from coal mines. The considerable experience in the United States of the use of liquefied petroleum gases, which are now becoming available in the United Kingdom as a result of the rapid extension of the oil refinery industry, could be profitably drawn upon by the British gas industry. In American carbonising practice the coals used are carefully selected and confined to a small range, and although the same facility for selection is not available in this country, the team conclude that "greater effort might be made to obtain more selective allocation of coal within the industry and to individual plant." The superior quality of American silica refractory material, it is thought, should be investigated more closely with a view to obtaining a longer life for coke ovens.

THE MAUDSLAY SOCIETY.

The eleventh annual luncheon of the Maudslay Society was held at Whitehall Court, London, on May 8, with Mr. O. D. Smith, President of the Society, in the chair. He explained that, owing to his other duties, Air Commodore F. R. Banks, C.B., O.B.E., M.I.Mech.E., was obliged to leave early, and accordingly the toast of "The Guests" was proposed by Col. C. F. Hitchins, D.S.O., M.I.Mech.E., and responded to by the Air Commodore, who then left. Col. Hitchins, in naming some of the guests present, mentioned particularly Mr. R. T. Collett, who was present and had been awarded the Henry Maudslay Foundation Scholarship of 150*l.* a year. The toast of the Maudslay Society was proposed by Mr. A. Roebuck, President of the Institution of Mechanical Engineers, who paid tribute to Henry

Maudslay and to those other famous engineers whose work had made present-day production methods possible. In replying, Mr. O. D. Smith, the President, said that Henry Maudslay, the son of a labourer employed at Woolwich, had that urge to rise and improve his lot which it was essential to instil into the youth of to-day, and he congratulated Mr. Collett on his achievement.

THE LONDON ASSOCIATION OF ENGINEERS.

The London Association of Engineers held their 101st Anniversary Festival at the Park Lane Hotel, Piccadilly, London, W.1, on Friday, May 9, under the chairmanship of their President, Captain B. H. Kimberley. The guests included Major-General S. W. Joslin, C.B., Director of Mechanical Engineering, War Office; Rear Admiral (E) G. C. Ross, C.B.E., A.M.R. Dept., Admiralty; Air Vice-Marshall R. G. Hart, C.B., Director General, Engineering, Air Ministry; and Mr. Parkin T. Sowden, acting chief, Methods and Equipment Division, Mutual Security Agency, American Embassy. In proposing the toast of the engineering industry, General Joslin pointed to three major contributions that engineers are making to society to-day: first, to civilisation in general, secondly as the premier contributor to economic recovery, and thirdly, in particular, the effort being made on behalf of the three armed Services. He continued by welcoming recent Government announcements of increases in higher technical education, but expressed his sincere hope that, in conjunction with this increase in education, encouragement would be given to maintaining the level of craftsmanship. In reply, Mr. H. Sammans, C.B.E., M.I.Mech.E., acknowledged the great responsibility of the engineering industry and continued by affirming that ultimate success would be achieved only so long as everyone concentrated on their own personal effort in respect of both education and practice. Mr. Sammans said that it was of great importance that the status of the production engineer should be raised, so as to attract more critically-minded engineers, in order that the industry itself should reject the inferior products that were being made in some works to-day. In responding to the toast of the guests, proposed by Mr. William J. Haycroft, treasurer and past-President of the Association, Mr. Sowden, of the American Embassy, acknowledged the abilities of British engineers, both past and present.

ANNUAL REPORT OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

The annual report of the Council of the Institution of Electrical Engineers for the year ended March 31, 1953, records that the membership of that body has now reached 37,782, an increase of 529 during the twelve months. As there was a significant rise in the number of graduates this discloses a healthy situation. There is, however, some doubt whether all these recruits are taking full advantage of the facilities provided by the Institution. In fact, the Council are concerned that more members should attend the numerous meetings, which are held in all the major cities and towns throughout the country, in order to discuss the papers representative of the whole field of electrical engineering which are presented on those occasions. The Council have continued to press for the development and extension of facilities for technological education, and in this connection it is interesting to learn that a Panel has been set up to consider ways and means of relieving the present shortage of text-books on electrical engineering, particularly those of a specialist post-graduate standard. Attention is also drawn to the success of an international conference on engineering education, which was held in London in 1953 and which enabled a better understanding to be obtained of the various methods employed. Considerable space is devoted to the Institution's own activities, including those of the various specialised sections, the local centres and the students' sections, and a full account is given of the technical investigations in which it participates through its representatives. These include matters relating to engineering codes of practice, overhead-line regulations, radio interference, electrical equipment of aircraft and general conditions of contract. The activities in which it engages jointly with such bodies as the British Standards Institution, the Professional Engineers Appointment Bureau and the Engineering Joint Council, are also reviewed.

OBITUARY.

MR. A. L. LUNN.

We regret to record the death of Mr. A. L. Lunn, which occurred at Belmont, Surrey, on Saturday, May 2. He was 69 years of age.

Alfred Lawrence Lunn was born at Northallerton on September 4, 1883, and received his early education at schools in that town and in Harrogate. At the age of sixteen he became a pupil of Mr. R. Falshaw, consulting engineer; and simultaneously attended evening classes at the Harrogate and Leeds Technical Schools. On the expiration of his time he continued in Mr. Falshaw's employment until 1906, when he joined the Electricity Department of the Manchester Corporation. Until 1910 he held various positions at the Stuart Street power station in that city, and then served as engineer-in-charge at the Hylton Road power station of the Sunderland Corporation for five years. He returned to Manchester in 1915 to become engineer-in-charge at Stuart Street, and during the next 22 years held different posts in the Manchester Electricity Department, becoming successively turbine-house superintendent, assistant resident engineer and resident engineer at Stuart Street. In 1925, he was appointed superintendent of power stations; and in 1927 deputy chief engineer.

In 1930, he left the local government service to become deputy electrical engineer to London Electric Railways and continued in the same position after the formation of the London Passenger Transport Board. In 1934, he was appointed electrical engineer (underground section), London Transport, and became electrical engineer (generation) three years later. He held this position until his retirement in 1948.

Mr. Lunn was elected a member of the Institution of Mechanical Engineers in 1928. He joined the Institution of Electrical Engineers as Associate Member in 1912 and was transferred to the class of member in 1925. He had served as honorary secretary and chairman of the North-Western Centre and as a Member of Council. He was also a Fellow of the Institute of Fuel and was the first president of the Electrical Power Engineers' Association.

Conference on Heat-Treatment Practice.—A conference on "Heat-Treatment Practice" has been arranged by the British Iron and Steel Research Association and will be held at Ashorne Hill, near Leamington Spa, on Monday, Tuesday and Wednesday, June 15, 16 and 17. Those taking part will assemble during the afternoon of June 15 and, in the evening, there will be a talk on the work of the Association's thermal treatment sub-committee. Papers to be read on the morning of June 16 will comprise "Steels Available for Engineering Purposes and not Requiring Surface Treatment," by Mr. H. Bull; "Problems Associated with the Heat Treatment of Engineering Steels," by Mr. H. Jackson; and "Metallurgical Problems Associated with the Heat Treatment of Large Forgings," by Mr. T. R. Middleton. In the afternoon of the same day, papers will be read on "Induction-Hardening Processes," by Mr. R. J. Brown; "Flame-Hardening Processes," by Dr. M. L. Becker; and on "Carburising and Nitriding, and the Heat Treatment of Components After These Surface Treatments," by Mr. C. C. Hodgson. Films depicting heat-treatment processes will be shown during the evening. On June 17, a paper on "Recent Developments in Isothermal-Heat Treatment, Including a Description of the Work of the Isothermal Transformations and Hardenability Group," by Mr. H. W. G. Hignett, will be read in the morning, and one on "Recent Developments in Methods for the Measurement and Control of Temperatures in Heat-Treatment Processes," by Mr. T. Land, in the afternoon. Applications to attend the conference should be sent to Mr. A. M. Sage, British Iron and Steel Research Association, 11, Park-lane, London, W.1, before May 20.

THE INSTITUTION OF NAVAL ARCHITECTS.

(*Continued from page* 583.)

The Spring Meeting of the Institution of Naval Architects was resumed on the afternoon of Thursday, March 26, on board of the Wellington, headquarters ship of the Honourable Company of Master Mariners, at Temple Stairs, London, by the presentation of a paper on "The Effect of Radial-Pitch Variation on the Performance of a Marine Propeller," by Professor L. C. Burrill, M.Sc., Ph.D., and Mr. C. S. Yang, M.Sc. The chair was taken by Sir Charles S. Lillicrap, K.C.B. A summary of the paper is given below.

Effect of Radial-Pitch Variation on Propeller Performance.

The work described in this paper was carried out by Mr. C. S. Yang, under the guidance of Professor L. C. Burrill, to ascertain the comparative effects of various forms of radial-pitch variation on the efficiency and performance of a marine propeller working in a uniform stream, and also in various non-uniform wake streams representative of twin-screw and single-screw wake patterns. At the outset, strip-theory calculations were made for an actual four-bladed propeller, of modern aerofoil section, as fitted to a twin-screw liner; the results were found to agree closely with expectations and with the tank-test figures. Investigations were then made for propellers in a uniform stream and for a propeller working in a variable wake, and for the original propeller working in different variable wake streams; and an examination was made of various methods of applying the condition of minimum energy loss, first introduced by Professor Helmboldt in 1927, to propellers working in a variable wake, to see whether these methods offered any advantage when applied to the variable-wake condition. The conclusions reached were that, from the point of view of overall efficiency, and apart from any consideration of cavitation, or breakdown of the flow, there appeared to be no material advantage to be gained by adopting a radial variation of pitch, either in a uniform or a variable wake stream; and, in particular, that there was no advantage in applying methods of design based on minimum energy loss, as any gain in the ideal or hydrodynamic efficiency could only be small and would be overshadowed by the effects of blade efficiency (i.e., section-drag losses, etc.) introduced by changes in the angles of incidence where the wake concentration was high. On the other hand, no special loss of efficiency was to be expected in the adoption of moderate pitch variations which were favourable from the point of view of cavitation or flow breakdown. It seemed that the quantity designated "relative rotative efficiency" had a real meaning and its value could be estimated by calculation. The nominal wake factor was slightly larger than the corresponding thrust-identity wake factor, and that, in turn, was somewhat greater than the equivalent torque-identity wake factor; the differences between the two factors were not greatly dependent upon pitch ratio.

Discussion.

The discussion was opened by Mr. R. W. L. Gawn, O.B.E., who said that the authors' conclusion that there was no material advantage to be gained from the adoption of a radial variation of pitch was very important, because, as the authors pointed out, the designer was thus free to use any variation that he might wish, with no cavitating and other conditions, vibration, etc.; but it appeared that it applied explicitly to the particular type of propeller investigated, of about 1·21 pitch ratio and 0·514 blade-area ratio. He asked if the authors considered that their work would justify a broader application. It had been established from model tests that a small improvement of propulsive efficiency, of the order of about 2 per cent., could be obtained by reducing the pitch of the propeller near the boss by as much as 20 per cent. Generally, the published results indicated that that was true for some, but not for all, types of single-screw merchant ships included in the investigation. That

feature had also been tested for the centre screw of a model of a triple-screw warship, but it was found that the propulsive efficiency was reduced by fully 2 per cent. as compared with a constant-pitch propeller. The paper indicated clearly that there was no material change; nevertheless, a change of 2 per cent. was by no means negligible.

Apparently, the propeller which had an increasing pitch from tip to root had a lower efficiency than others in a wake of 0·3; namely, 0·68 in one case (No. 2), as compared, for example, with 0·71 for another (No. 5). That difference was equivalent to 4 per cent. of the machinery horse-power, which was quite important, and prompted the question whether the authors had arranged for any experiments to confirm the results. If not, they might care to consider whether it would not be worth while to do so. He was rather surprised that the propeller of constant pitch had not been included in the comparison, for many propellers were of constant pitch. The paper mentioned a variety of methods of assessing the minimum energy loss, and he asked whether the authors had arrived at any conclusion regarding the best method to follow.

Professor W. P. A. van Lammeren found that, generally speaking, the results of the authors' analysis were in agreement with his own experience. The widely different pitch variations examined showed only small differences in overall efficiency, both in a uniform and a variable velocity field, if the effect of the rudder were neglected. It had been proved by theory and experiment that an advantage could be gained from an extra increase of pitch towards the propeller boss if there were a rudder behind the propeller. The results of calculations for the original propeller, working in different variable wake streams, showed clearly that splitting the overall efficiency into its components was only of academic interest so long as the determination of the mean speed of advance depended on a rather arbitrary definition. Actually, the calculation of the propulsion components became still more complicated if the effect of rudder, non-homogeneity of flow in the circumferential direction, and, consequently, unequal distribution of thrust deduction over the screw disc were taken into account. If the components were deduced in the usual way from model test results, the latter effects were automatically included therein. They could be analysed separately, however, if the usual open-water test were replaced by a propeller test in a velocity field equal to that behind the model or ship in question. That could be done in a cavitation tunnel provided with means for reproducing arbitrarily-given velocity fields. Such means were under construction for the cavitation tunnel of the Wageningen ship-model basin, of which he hoped to be able to give particulars in a future paper to the Institution. He agreed with the authors that there was no special advantage to be gained from the application of the various alternative methods of design, based on the principle of minimum energy loss, to the types of sections indicated. If those methods were used, however, applying sections with shock-free entrance (Karmàn-Trefftz sections), which had very favourable cavitation characteristics, the blade-area ratio might be decreased compared with that necessary for propellers having sections of orthodox shape. That would lead to an improvement in efficiency of 2 or 3 per cent. The main advantage of the adoption of those procedures, in his opinion, was that it enabled cavitation-free propellers to be designed with a fair degree of accuracy. A condition for minimum energy loss had been published ("The Design of Ship Screws of Optimum Diameter for an Unequal Velocity Field," by Dr. J. D. van Manen, *Trans. S.N.A. & M.E.*, 1952). It led to a smaller increase of pitch towards the boss than that given by van Manen and Balhan.

Professor E. V. Telfer thought that it was not generally appreciated how restricted the series of investigations described really was. In the first place, the authors, in their calculations, were not dealing with model propellers, but with full-scale propellers. The authors would probably agree that, if a similar investigation were made on the model scale, the results would be different. The influence of blade resistance could not be ignored entirely. There was still an inter-relation between blade resistance and pitch, and it became extremely difficult to divorce the two problems. Good as the authors' method was—and he could testify that it was good—it might not be sufficiently penetrating or decisive to test those particular issues, and he agreed with Mr. Gawn that it would be interesting to see the calculations checked by model experiments. With regard to the authors' reference to what they termed "virtual efficiency," they made the rather cryptic statement that that efficiency had been previously described as a "real" efficiency; and the reference that they gave showed that they were referring to a paper entitled "Ship Propulsion Miscellany" which he (Dr. Telfer) had read before the North-East Coast Institution of Engineers and Shipbuilders in 1951. What else could it possibly be than the true efficiency? The "thrust-identity efficiency" was not an efficiency; it was useful to call it so, but it was not efficiency in the real sense of the word. It might be termed a pseudo-efficiency. He would like Professor Burrill to explain his point of view at greater length. The authors appeared to think that, by getting higher and higher nominal efficiency, they were getting higher results, whereas actually they were getting the exact opposite. If they endeavoured to improve the nominal efficiency, they were making the real efficiency worse.

Mr. A. Silverleaf said that the paper advocated a most admirable and desirable use of propeller theory for accuracy in comparative calculations. The discussion in the paper of the alternative methods of assessing propeller efficiency in variable wakes, based on the different mean advance speeds, helped to clarify the problem considerably. Some twelve months earlier, at the National Physical Laboratory, the experiments that Dr. van Lammeren indicated were begun. At once, the problem arose of how to assess the mean speed of advance, and, quite naturally, they also had arrived at the various methods which Professor Burrill and Mr. Yang had summarised—the integrated mean velocity or volumetric mean, etc. All of those could be measured, but the virtual efficiency, the true mean efficiency, could not be measured in that way.

Following from those investigations came the discussion on relative rotative efficiency; the analysis in the paper helped towards an understanding of the physical meaning of that term. Previously, he had always considered it to be simply a measure of the change between the torque coefficient in the behind and open conditions with the thrust-identity method and the torque-identity method; why there should be a difference between the two methods he could not understand. It was clear from the paper that relative rotative efficiency should be considered as a ratio in going from uniform speed to a flow in variable conditions. If that were the case, it seemed opportune to attempt to dispose of the term "relative rotative efficiency" and to substitute a more useful term. It might be called the variable-flow factor or ratio, or even the variagle-flow efficiency factor. The statement that no significant gains or losses in efficiency occurred by making reasonable pitch variations accorded well with modern design experience.

Mr. B. N. Baxter said that the authors had shown for the first time that there was no gain in efficiency from the adoption of a radial variation in pitch, in either a uniform stream or a variable-wake stream. The nominal efficiencies η_N of the several pitch variations were compared with η_N obtained by using propellers designed for various minimum energy-loss conditions; in particular, η_N for the Betz condition decreased rapidly as W_N increased, when compared with the others. The total pitch variation from tip to root of the Betz propeller was about 0·46 metre when $W_N = 0·225$, and 6·8 metres when $W_N = 0·34$. It was suggested that the latter very high pitch variation placed the Betz condition outside the range of a true η_N comparison with the standard propellers. The same argument might probably be applied when $W_N = 0·30$. He invited the authors' comments on the point.

Dr. J. F. Leathard, commenting on the Betz condition to give optimum efficiency, thought that it should be made clear that the Betz condition applied to hydrodynamic efficiency, and that no account had been taken of the blade efficiency for those particular sections. Thus the Betz condition, to write it in a different form, implied that the hydrodynamic pitch angle was inversely proportional to the radius, which meant that it gradually increased towards the root of the propeller. That actually implied that the root sections were operating at very unfavourable angles of incidence and giving rise to bad blade efficiency. If a propeller having good hydrodynamic efficiency could be produced, that automatically implied that the blade efficiency was worse than it was in the previous condition. Further, the thrust coefficient obtained with any particular blade section was dependent on circulation at that section, which was dependent in turn on the hydrodynamic pitch angle. The thrust coefficient, and consequently the lift coefficient, was directly related to the circulation of that section. Therefore, if a certain hydrodynamic pitch angle were decided upon, the effect was automatically to fix upon a certain thrust coefficient and lift coefficient in that section. If an attempt were made to design a propeller on the basis of the optimum Betz condition, it would always be found that the circulating inflow factor coincided with the basic propeller, but it would vary with any departure from that particular section. He had tried to modify the Betz condition to take account of the blade friction of each particular section. It was possible to show that there was some modification to the inflow angle which was dependent upon the ratio of lift to drag coefficient. He had tried out one or two pitch variations on that basis, but it did not seem to make a great deal of difference to the overall effect. He asked if the drag of the boss of the propeller affected the calculations.

Professor Burrill, replying to the discussion, agreed that he and Mr. Yang might have said that there was no gain from the adoption of a radial variation of pitch, but he preferred to say there was no "material" advantage to be derived from that particular method. There was no suggestion that they were going to measure a material advantage of 1 or 2 per cent. or any amount. He was glad to have the support of Dr. van Lammeren, from the Wageningen tank, and of Mr. Silverleaf, from the N.P.L., that their general conclusion agreed with present-day experience. He suggested that Dr. Telfer was referring to the past; in 1934-36, he himself would have taken the same view. The suggestion that the rudder might have an effect on the calculations was an important one, but they had no means of calculating that effect. It was interesting to know there were to be some tunnel tests. Had they been in a position to test their propellers in a tunnel, they would have done so; he hoped to be able to test some of them in that way. Unfortunately, the influence of scale effect on the model test sometimes worked one way and sometimes another; it was a good thing, therefore, that they could divorce an examination of that kind from the incidental errors of some of the tests, and see what, on broad lines, they might expect. Regarding the terms "virtual" and "real" efficiency: the term "real efficiency" was, in fact, used by Mr. Yang, but he (Professor Burrill) had objected to applying the word "real" to something which was elusive and could not be obtained. It was very unreal, and so they decided on the word "virtual." He believed that, out of the difficulties encountered, there had come an appreciation of the problem of variable pitch; certainly, it had led him to an understanding of relative-rotative efficiency which he did not possess before. He agreed with Mr. Silverleaf that another name might be advisable; if he could suggest one, it might be adopted by the British Shipbuilding Research Association.

(To be continued.)

VACATION WORK FOR STUDENTS.—The National Union of Students, 3, Endsleigh-street, London, W.C.1, offer a liaison service between employers desiring to engage temporary labour during the period July 1 to October 5, and university students wishing to undertake vacation work. The Union hold an exemption certificate from the Ministry of Labour Notification of Vacancies Order and can therefore place students without prior reference to the Ministry.

THE BRITISH INDUSTRIES FAIR AT BIRMINGHAM—IV.

IN this article we conclude the series dealing with some engineering exhibits at the Castle Bromwich section of the British Industries Fair. The Fair closed last Friday, May 8.

WASHING AND DEGREASING PLANT.

Washing and degreasing equipment on the Gas Council stand included an insulated degreasing tank by the Dowson and Mason Gas Plant Company, Limited, Manchester, with a gas consumption of 215 cub. ft. per hour, which can be heated from 60 deg. to 212 deg. in 2½ hours. It is heated by an atmospheric jet burner firing concentrically into a horizontal immersion-tube coil, terminating with a vertical flue stack. The burner is fitted with a gas governor and thermostatic control.

For washing and degreasing metal parts, a washing plant by the Edward Curran Engineering Company, Limited, Cardiff, was exhibited. It can be installed in an assembly line so that parts are continuously discharged, or it may be loaded and unloaded by hand. The speed (normally 1 ft. per minute, allowing a 2-minute wash) can be varied by altering the driving sprocket or by fitting a variable-speed drive. The washing fluid is heated by six immersion gas-fired tubes, thermostatically controlled and fitted with a governor and safety cut-out.

GAS-FIRED FURNACES.

The exhibits on the Gas Council stand illustrated the application of gas in the non-ferrous metal industries, where it is widely used, on account of the certainty and ease with which it can be controlled, for processes such as die-casting, degreasing, melting, soldering, brazing, hot-brass stamping, and steam-raising. Shown in Fig. 46, on page 624, is a continuous sealed brazing furnace with an atmosphere plant manufactured by the Incandescent Heat Company, Limited, Smethwick. It is heated by a series of Incandescent Spiro-Ray radiant tubes working with boosted town's gas at 12 in. w.g. pressure and combustion air at 16 in. to 18 in. w.g. pressure. Combustion takes place inside each radiant-tube coil, the system of firing ensuring rapid and economical heat transfer to the work. The coils are supported on nickel-chromium stools and the furnace mattress is carried on floor plates in a nickel-chromium alloy of high heat conductivity.

The furnace, of high-grade refractory materials, is backed by an insulation course about 9 in. thick. It is fitted with a continuous conveyor belt, of woven nickel-chromium wire with reinforced edges to prevent fraying in service, driven by an electric induction motor coupled to a variable-speed unit and double reduction gearing. A tensioned pressure roller is incorporated in the system.

The performance of the furnace is estimated as follows: maximum gas consumption, based on gas with a calorific value of 500, when lighting up, 420 cub. ft. per hour; for maintenance, 160 cub. ft. per hour; and for production, 360 cub. ft. per hour. The work "through-put" would be about 60 lb.

The atmosphere plant is fitted with a Selas-type mixer, taking air and gas in varying proportions and delivering the mixture to an air-cooled burner in a brick-lined combustion chamber. From the latter the products of combustion pass through a series of tubes in the heat exchanger and thence into a cooler where water vapour is condensed. From the cooler, the gas passes into a desulphurising unit to remove all hydrogen sulphide. Finally, the gas passes to one of two silica-gel drying units. Hot air for regeneration is provided by a motor-driven blower which drives air round the tubes in the heat exchanger, in contra-flow to the products of combustion leaving the combustion chamber. The heated air can be utilised to provide heat for re-activating the silica-gel unit not in service.

Also on view on the stand of the Gas Council was a demonstration by Monitor Engineering and Oil Appliances, Limited, of electro-gas brazing equipment, supplied by Standard Telephones and Cables, Limited, for mechanising the production-brazing of standard assemblies for Monitor blowlamps and pressure stoves; a pneumatically-operated die-casting machine made by Messrs. William Coulthard and Company, Limited, Carlisle, for the continuous production of small zinc, lead, or tin alloy pressure die-castings; and a hot brass-stamping furnace by Universal Furnaces, Limited, Tipton, Staffordshire, with an 18-in. by 10-in. hearth, consuming 200 cub. ft. of gas per hour. The furnace is self-contained and portable, air being supplied by an electrically-driven fan built into the framework. A feed chute over the top of the furnace serves also as an outlet for waste gases, giving some preheat to the pieces at the base of the chute. The furnace body can be readily changed and gas with a lower calorific value can be used without altering the burners.

Fig. 47, on page 624, shows a new bale-out furnace for aluminium melting by Thermic Equipment and Engineering Company, Limited, Salmon-street, Preston, also exhibited on the Gas Council stand. It includes a billet pre-heating compartment built into the waste-gas flue of the furnace; the use of pre-heat, it is claimed, results in a 10 per cent. increase in output for the same gas consumption. It is heated by two Thermic Eddy Ray gas burners suitable for operating with air at 8 in. w.g. pressure and town's gas at 2½ in. to 3 in. w.g. pressure.

FORK-LIFT TRUCK WITH WEIGHING EQUIPMENT.

The Stacatruc fork lift truck model 45 EH/9 was described on page 580, in the previous article, and in Fig. 48, on page 624, of this issue the same truck is shown fitted with the "Wheelerweigh" automatic weighing equipment; this equipment enables the operator to observe the exact weight supported by the forks, on a dial mounted before him. It has been approved by the Board of Trade Standards Department, and it is thought that it should satisfy the requirements of national bodies governing the use of weighing machines for trading purposes. The equipment can be fitted to any one of the present range of Stacatrucs. The weighing mechanism is based on the beam principle of weighing, and works on renewable and interchangeable hardened steel knife-edge centres and bearings that have been designed to withstand rough treatment. The whole of the equipment is locked and rigidly held in position until required, and is released for weighing by depressing an operating lever. When locked the mechanism is completely relieved of all loads and shocks caused by any buffeting of the truck movement and loading, and it is totally enclosed so that it cannot be tampered with after having been approved. The weight reading is shown on a large engine-calibrated dial with widely spaced divisions that can be easily read, and it can be placed across the vehicle in front of the driver or arranged for side reading. It is fully illuminated when operating and it can be supplied for any weight scales, i.e., lb., kilograms, etc.

CABLE-DRUM CARRIER AND LAYER.

Messrs. Whitlock Brothers, Limited, Great Yeldham, Essex, exhibited two- and four-wheeled trucks and other vehicles, including examples of the "Handiway" form of trailer construction, which was first marketed last year. With this form of construction, the whole vehicle is built up from a series of interlocking pressed steel panels; these vehicles are of particular value to the export market for the panels pack well to effect savings on freight charges. Among the new vehicles on view was a cable-drum carrier and layer, illustrated in Fig. 49, on page 624, and a side-tipping dumper; both these models are designed for towing behind lorries or suitable tractors, and are fitted with pneumatic tyres and over-run brakes. The cable-drum carrier, which is easily loaded and unloaded, has been designed for loads up to 5 tons in weight and for drums up to 6 ft. in diameter. Although the standard model is fitted with tyres, as illustrated, there is also available a set of interchangeable rubber-jointed tracks for use over bogs and swamps.

"DINKUM" DIGGER.

The centrepiece of the exhibits of Messrs. Whitlock Brothers, however, was the Dinkum digger, illustrated in Fig. 50, on page 624. The digger, a compact trenching and general excavating machine, is designed for mounting behind tractors fitted with a rear power take-off. The power unit is a single hydraulic pump, developing 2,000 lb. per square inch, mounted in the centre of the machine, and coupled to the power take-off through a Hardy Spicer universal coupling. Control of the three movements of lifting, slewing and digging is maintained by three simple levers; stalling of the tractor engine and damage to the hydraulic system are prevented by a specially designed relief valve which allows full power to be maintained even when working in difficult ground.

About 20 minutes are required to fit the digger to a tractor, and it can be dismounted in ten minutes. A feature of the machine is the linkage that has been employed to correct the digging angle at all depths and to ensure that loose soil is held when the bucket is being withdrawn. The digging and lifting rams are located above the jib, where they are protected from damage by soil abrasion or careless handling. During the working stroke, resistance to movement is provided by the skid pads digging into the ground; their flexible mounting, however, enables them to ride over rough ground during forward travel of the excavator. The weight of the Dinkum digger is 11 cwt., and the standard bucket, 22 in. wide, has a struck capacity of 4 cub. ft. and a maximum depth of cut of 6 ft. 6 in., combined with a possible slew of 50 deg. to either side.

DIESEL GENERATING SET.

The Diesel generator shown in Fig. 51, opposite, is manufactured by Dale Electric (Yorkshire), Limited, Filey, Yorkshire. Two sizes of this type of generator are made: a 3-kW set, which is driven by a Petters AVI series II Diesel engine, and a 6-kW set powered by a Petters AV2 series II Diesel engine. Both sets can be arranged to start automatically when a lamp or other electrical appliance drawing current from it is switched on, and they can also be fitted with a remote control starting gear, or for simple hand starting. It is claimed to be the only generating set of its type manufactured in the United Kingdom that has received Canadian Standards approval. The coupling between the generator and engine is designed to enable the generator to be removed in a matter of a few minutes for servicing.

The generator is built to British Standard Specification No. 168-1936. It is drip-proof and fan ventilated. Heavy-duty ball bearings carry the rotor. The rating is normally 240 volts, single-phase, 50 cycles with a power factor of unity, but it can be made for other voltages at 50 or 60 cycles. It has starting windings, a battery-charging circuit, and is a self-exciting and self-regulating type of generator. The control box and switchboard, carried directly above the generator on anti-vibration mountings, contain relays for the automatic starting. Should the set fail to start because of a fuel blockage, or other reason, one of the relays will stop a complete discharge from the battery by preventing the functioning of the automatic starter. The decompressor and fuel control are actuated by an electric solenoid, and a controlling relay prevents the application of full load until the engine reaches maximum speed.

The engine used on the 3-kW set develops 5 brake horse-power at 1,500 r.p.m., and the engine of the 6-kW set develops 10 brake horse-power at the same r.p.m. They are one-cylinder and two-cylinder units, respectively, and are water-cooled and run on the four-stroke cycle. A 15-gallon gravity fuel tank is normally used and wall brackets and a 4-ft. length of flexible pipe are supplied with the engine. The air intake is the oil-washed type. The fuel oil is fed through a filter to the direct-injection type of combustion system and fuel consumption at full load is 0·43 lb. per brake horse-power-hour. A centrifugal governor controls the engine speed to comply with British Standard Specification 649-1949. Cooling of the engine is by a fan-assisted radiator, but it can also be arranged for cooling from a large water tank. An air-cooled model is to be made later. Pressure lubrication is fitted, and the exhaust silencer is of the "pepper pot" type. The engine is mounted on a fabricated

EXHIBITS AT THE BRITISH INDUSTRIES FAIR.

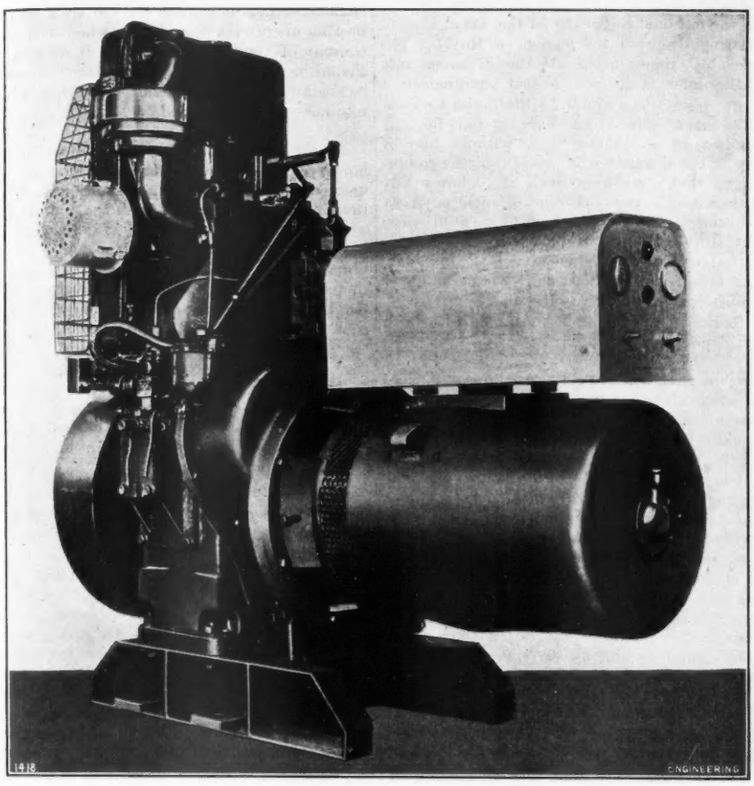


FIG. 51. DIESEL GENERATOR SET; DALE ELECTRIC (YORKSHIRE), LTD.

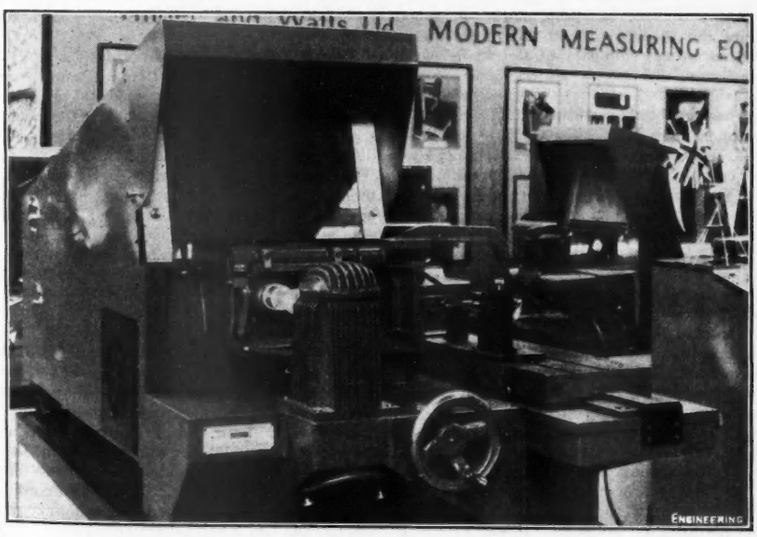


FIG. 52. HILGER TURBINE-BLADE PROJECTOR; ALFRED HERBERT, LTD.

steel base of 4 in. by 2 in. channel, and the generator is bolted by flanges directly behind the geared end of the engine crankcase.

TURBINE-BLADE PROJECTOR.

Alfred Herbert, Limited, Coventry, were exhibiting the Hilger TT.693 turbine-blade projector, which is designed for the examination of blade sections by comparison with a photographic or smoked-glass drawing of the sections to be examined, both sides of blade being tested simultaneously. The blade is mounted on a carriage with a longitudinal traverse of 14 in. A stylus contacts each side of the blade section, with a light spring pressure between them of approximately $\frac{1}{2}$ oz. The stylus mounts are attached directly to a pair of frames on which a pair of photo-plates of the sections to be examined are mounted. One plate contains all the convex sections and is attached to the frame carrying the stylus which will contact the convex side of the blade, while the other plate contains the concave sections of the blade and is attached to the frame to which the stylus contacting the concave section is attached. The emulsion sides of the two plates are face to face but slightly separated so that both photo sections can be projected together in focus at $\times$ 20 magnification. Both frames have free horizontal movement and are carried together on a carriage with a vertical movement of 4 in. so that the stylus can be traversed across a section of the blade. On the projection screen a circle is drawn whose diameter is 20 times the diameter of the stylus ball point of $\frac{1}{16}$ in. diameter. The tolerance can be indicated by a circle larger or smaller than the nominal size circle. When the section of the blade is within the specified tolerance, the convex and concave images projected on the screen from the photo-plate should pass within the tolerance area defined by the inner and outer circles as the styluses are traversed across the blade section. The stylus will traverse round the leading or trailing edge as far as the ball tip will allow, but the extension of the movement up to the tangent point for each tip can be obtained by restraining the movement of the opposite frame. The carriage on which the blade is mounted can be located by slip gauges from a fixed stop so that the required movement can be obtained to locate the position of the blade sections to be tested. Two T-slots are provided on the carriage for the blade clamps or the special fixtures. The carriage can be swung over at any angle up to $\pm$ 5 deg. if desired, so that different sections are displaced relative to each other. In this case the projection-screen nominal circle will be replaced by a circle for each section, each displaced to correspond to the displacement of each section. The horizontal traverse of the stylus bars is $3\frac{1}{2}$ in., and the maximum permissible blade thickness is $1\frac{1}{4}$ in. The length of the work stage is 18 in. and the width is 6 in.

LAUNCHES AND TRIAL TRIPS.

M.S. "WYUNA."—Twin-screw pilot vessel, accommodating 20 pilots, built by Ferguson Brothers (Port-Glasgow), Ltd., Port-Glasgow, for Port Phillip Sea Pilots' Association, Melbourne. Main dimensions: 185 ft. by 39 ft. by 22 ft. 6 in.; gross tonnage, 1,400. Two Diesel-electric engines, developing a total of 1,400 s.h.p., constructed by the English Electric Co., Ltd., London, W.C.2. Launch, April 15.

S.S. "ALGOL."—Single-screw dredger, built and engined by Chantiers et Ateliers Augustin Normand, Le Havre, France, for the French Navy. Main dimensions: 151 ft. 11 in. by 27 ft. 11 in. by 7 ft. 6 in. displacement, 424 tons. Double-reduction geared gas turbine, developing 1,800 h.p. Speed, 15 knots. Launch, April 15.

S.S. "ATLANTIC BARONESS."—Single-screw oil tanker, built and engined by the Fairfield Shipbuilding and Engineering Co., Ltd., Glasgow, for Atlantic Oil Carriers, Ltd., London, E.C.3. Main dimensions: 545 ft. by 71 ft. by 40 ft. 5 in.; deadweight capacity, 19,500 tons on a draught of 31 ft. 1 in. Double-reduction geared turbines. Launch, April 15.

M.S. "BURMAH STAR."—Single-screw oil tanker, built by Cammell Laird & Co., Ltd., Birkenhead, for the Burmah Oil Co. (Tankers), Ltd., London, E.C.2. Main dimensions: 407 ft. 5 in. by 56 ft. by 31 ft. 3 in.; deadweight capacity, 8,500 tons on a draught of 25 ft. Sulzer five-cylinder marine Diesel engine, developing 3,500 b.h.p. Launch, April 16.

M.S. "HOPEMOUNT."—Single-screw oil tanker, built by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne, for the Hopemount Shipping Co., Ltd. (Managers: Stott, Mann and Fleming, Ltd.), Newcastle-upon-Tyne. Main dimensions: 526 ft. between perpendiculars by 72 ft. 6 in. by 40 ft. 6 in.; deadweight capacity, 19,010 tons on a draught of 31 ft. $5\frac{1}{2}$ in.; oil-tank capacity, 849,415 cub. ft. Wallsend-Doxford six-cylinder opposed-piston two-stroke oil engine, developing 8,000 b.h.p. at 104 r.p.m. in service, constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Service speed, $14\frac{1}{2}$ knots. Trial trip, April 28.

S.S. "BORDE."—Single-screw collier, built by S. P. Austin & Son, Ltd., Sunderland, for Stephenson Clarke, Ltd., London, E.C.3. Main dimensions: 344 ft. overall by 46 ft. by 22 ft. 4 in. to upper deck; deadweight capacity, about 4,600 tons on a mean summer draught of 20 ft. Direct-acting triple-expansion engine of reheat design, constructed and installed by the North Eastern Marine Engineering Co. (1938), Ltd., Sunderland, and two oil-burning boilers. Service speed, $10\frac{1}{2}$ knots. Launch, April 28.

S.S. "CALTEX MANCHESTER."—Single-screw oil tanker, built and engined by R. and W. Hawthorn, Leslie & Co., Ltd., Hebburn-on-Tyne, County Durham, for the Overseas Tankship (U.K.), Ltd., London, W.1. Main dimensions: 544 ft. 4 in. by 70 ft. by 39 ft. 9 in. to upper deck; deadweight capacity, 17,450 tons. Double-reduction geared steam turbines, developing a maximum of 8,200 s.h.p., and two Yarrow water-tube marine boilers. Speed, 15 knots. Launch, April 29.

THE INSTITUTION OF WATER ENGINEERS.

AT the summer general meeting of the Institution of Water Engineers, held at Southend-on-Sea, on May 13, 1953, Mr. W. C. Knill, B.Sc., M.I.C.E., President of the Institution, said that the increase in the total number of all grades of members of the Institution was greater during the past ten years than it had been during the previous forty years.

In the matter of recruitment, training and service, he said that steps should be taken to ensure that the opportunities in water engineering were made known to all engineering students as they approached the end of their university training; many recruits appeared to enter the water industry by accident, with an extremely vague idea of the work involved and of the prospects. He accordingly suggested that, each year, the water industry should offer at least one travelling scholarship to a graduate engineer, sufficient in value to maintain him reasonably well, that the holder might have the opportunity to gain experience on different types of works, either at home or abroad. In regard to research, he said the water industry had lagged behind other industries in organising research, and that no physical effort or financial expenditure should now be spared. The formation of the Research Committee had resulted in the immediate realisation of the immense amount of work to be done, and he considered an independent fully-equipped laboratory should be provided with the least possible delay. Speaking on the question of the future demand for water, he quoted the description of the estimation of future demand, given by Mr. H. F. Cronin, C.B.E., President of the Institution of Civil Engineers, as "that pitfall of so many prophets," and said, "However, the estimate must be made. If the estimate is too high, needless expenditure is incurred. If it is too low, the catastrophe of a shortage of water may occur." The problem had received exhaustive consideration, and an increase in the demand for water was an inevitable consequence of the national housing programme; also, he believed there were sufficient indications to show that the water industry would be faced with a steadily increasing rate of consumption over the next 20 or 30 years. The problem of future supplies, he said, was particularly difficult in that part of England lying between the River Severn and the East Coast, which included the Greater London area, and he suggested we may now be approaching the time when water must be brought across England from the wetter to the drier side of the country; a scheme of such magnitude, however, would have to be very carefully examined.

Turning to future developments, he said the advocates of fluoridation of water supplies had made a good case for reducing the incidence of dental caries by this method, and that the report of the team of experts from the Ministry of Health, who visited the United States to investigate the work on fluoridation carried out in that country, was awaited with interest. Looking into the future, he wondered whether the day would come when television would aid in the underwater inspections of wells and boreholes, and the chemical laboratories would lose their bottles and become a mass of electronic apparatus.

BRITISH ELECTRICITY AUTHORITY SCHOLARSHIPS.—Last year the British Electricity Authority and the Area Boards, on the recommendation of the National Joint Advisory Council, inaugurated a scheme whereby 12 scholarships were offered each year to their employees for full-time studies at a university or college for periods from six months to three years. Of these scholarships, six are allocated to manual workers and six to the technical, clerical and administrative staffs. During 1952, 248 applications (96 from technical, 77 from clerical and administrative, and 75 from manual employees) were received. Awards were made to Messrs. R. H. Aldham-Hughes, B. H. Davolls, G. S. Franklin, J. A. Hope, R. H. J. Leaney, and E. Prince, among the manual employees; and to Messrs. P. D. Aylett, R. W. Diggens, K. H. Hughes, J. M. Russell, M. A. Shepperd, and J. E. M. Watts among the technical, clerical and administrative staff.

LABOUR NOTES.

FOUR hours off the working week in the engineering industry were demanded at the annual conference of the national committee of the Amalgamated Engineering Union at the session on May 5. The 52 delegates, representing all the divisions into which the union is divided, passed unanimously a composite resolution requesting the union's executive council to take immediate action for the introduction of a 40-hour week without loss of earnings. The delegate who introduced the resolution urged that a working week of 40 hours was needed to minimise the possibility of unemployment and to enforce the rights of employees to more leisure. He took the view that there had been a substantial increase in productivity in the industry, and that this had meant that more work was being accomplished more quickly. It was now up to the union, therefore, to take steps to minimise the risk of unemployment.

Assertions that whenever the working week had been shortened, employees had responded, and that production had consequently invariably increased, were made by the delegate who seconded the resolution. One speaker suggested that, if the union delayed demanding shorter hours, the employers might forestall them by asking for a longer working week. Most delegates considered that a 40-hour week could be financed out of the "tremendous profits being made in the industry." Others claimed that the real need for a shorter working week arose from the increase in unemployment and from a fear of being discharged owing to redundancy. There was a suggestion that if the employers found it difficult to comply with the demands, their employees were prepared "to take over" the industry.

Only one speaker struck a discordant note. He suggested that the real reasons behind the demand for a shorter week were that any shortening of working hours would enable overtime payments to start that much earlier. Speaking in another connection, a delegate from a London division said "Let us share out the shrinking market for labour by sharing out the hours," and this might well be regarded as an apt summary of the whole of the delegates' case. It may be stated, however, that the desirability of shortening the working week to 40 hours has long been one of the principle objectives of the Amalgamated Engineering Union and that when the present week of 44 hours was agreed to by the employers in 1946, this concession was regarded by the union as being merely an instalment on behalf of better things to come.

Demands that the union's executive council should press for an additional three days' paid holiday each year were also put forward and carried without dissent. A resolution, calling for the payment of holiday money to be based on the individual's average earnings in a week of 44 hours, was discussed at some length, and eventually withdrawn when it was realised that the Confederation of Shipbuilding and Engineering Unions was already pressing for such an arrangement to be made. Operatives who took an extra week's pay instead of a week of their holidays were roundly condemned during the debate, mainly because such action appeared to weaken the union's claim that its members needed good holidays. It was even suggested that such conduct should be punished. Efforts to exclude the Press from meetings of the national committee were heavily defeated. Mr. Jack Tanner, the union's President, reminded the delegates that the committee decided years ago that the Press should be admitted. Many distorted versions of the union's decisions had appeared in the newspapers when pressmen were not present.

The long composite resolution which was debated on May 5 covered a very wide field. It expressed concern at the increase in unemployment and called upon the executive council to take a number of measures to counteract redundancy. In addition to the operation of a 40-hour week, these included requests that prior consultation should take place with union representatives before redundancy was declared in any establishment, that no overtime should be worked in any department or section of a works where redundancy was likely to take place, that Government centres for the training of engineering operatives should be allowed only with the consent of the union, and that lump-sum grants should be paid to employees on their being declared redundant. The arguments connected with this resolution were continued on May 6.

By far the greatest amount of time on May 6, however, was devoted to consideration of the union's wage policy and a resolution in favour of pressing for an increase of 3*s.* in the pound all round was carried unanimously. This decision is in line with the recommendation of the Confederation of Shipbuilding and Engineering Unions that a claim should be presented to the engineering and shipbuilding employers for an overall increase of 15 per cent. for employees in these industries. In view of the substantial voting strength of the A.E.U. in the Confederation, as compared with that of the other 37 unions affiliated to that body, it seems certain that the recommendation for making a claim for a 15 per cent. increase will be carried when the subject comes before the Confederation on Wednesday next for final decision.

During the committee's debate on wages, much attention was given to the question of getting the rank and file of the union, and if possible the general public as well, to support a wage claim. Many delegates urged that a special publicity campaign should be inaugurated to this end, and a resolution was passed requesting the executive council to use every means to obtain publicity for the justice of the union's case. Mr. William Hutchinson, who introduced the debate on behalf of the executive council, considered that an advance of 3*s.* in the pound could not be regarded as otherwise than "reasonable, sensible, logical and practicable," having regard to the rise in the cost of living. At the same time, the council did not wish to base the claim on that ground alone. Increased productivity, wider profit margins and the extra skill now demanded from engineers, were other good reasons.

In his presidential address to the conference, which is being held at Eastbourne, and opened on May 4, Mr. Jack Tanner made some forthright remarks on wage claims, nationalisation and trade with "iron curtain" countries. He told the delegates that the claim last year for 2*l.* a week was "transparently unrealistic." Any wage claim the union made was doomed to failure unless it was accepted by the members as reasonable and practicable. When the union had to spend time and money persuading its own members that they were entitled to an increase of as much as 2*l.* a week, the position became farcical. The conference is due to end to-morrow.

Work was found for no fewer than 24,937 of the 32,137 ex-Service men and women who registered with the National Association for Employment of Regular Sailors, Soldiers and Airmen during 1952. Colonel J. J. Astor, the President, stated at the Association's annual general meeting in London, on May 1, that this was about 8,000 more placings than for the previous year. This was, he considered, a very gratifying result for the efforts made by the Association, and much help in achieving it had been given by the Service departments, which had enabled members of the organisation's staff to get into contact with men and women in the Armed Forces before they were discharged. A very great deal depended on the good will of employers.

The guest speaker at the meeting, Lieutenant-General Sir Ronald Weeks, chairman of Messrs. Vickers, Limited, stated that it would always give him pleasure to feel that industry was being continually stiffened by men and women who had served their time in the regular Forces. Workpeople of this type, as a result of their training and discipline, possessed comradeship, good sense, and leadership abilities, and were in a position to make a first-class contribution to the nation's economy.

ELECTRICALLY-DRIVEN COGGING MILL.

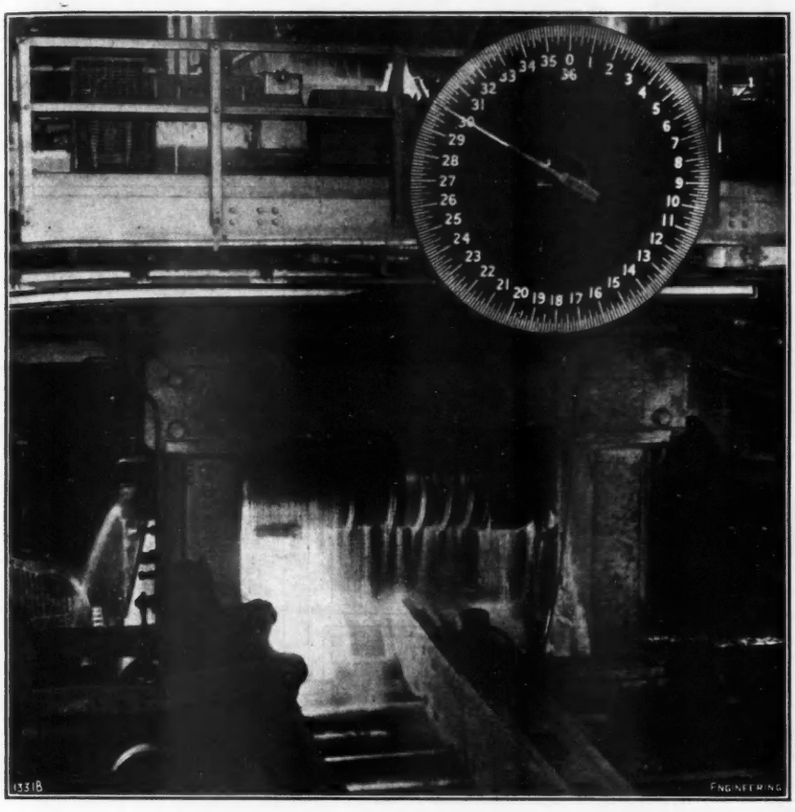


FIG. 1. VIEW OF MILL WITH INGOT ENTERING ROLLS.

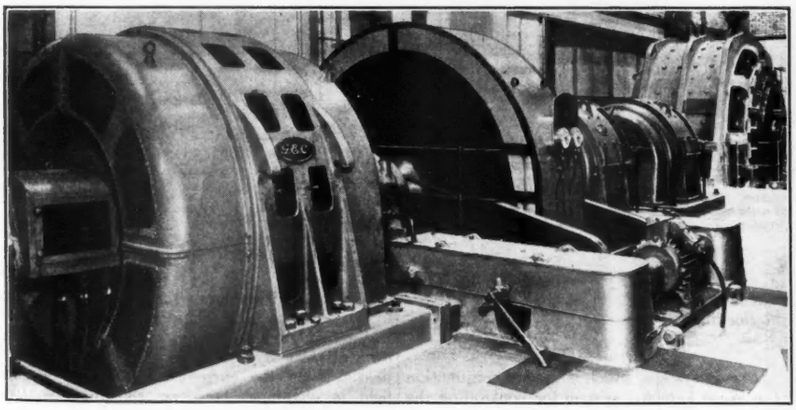


FIG. 2. 3,000-H.P. WARD LEONARD ILGNER MOTOR-GENERATOR.

ELECTRICALLY-DRIVEN 42½-IN. COGGING MILL.

THE equipment at the Redbourn works of Messrs. Richard Thomas and Baldwins, Limited, 47, Park-street, London, W.1, includes four long-type regenerative soaking pits, which are fired with a mixture of blast-furnace and coke-oven gases, and a one-way fired pit burning coke-oven gas alone. Each of these pits is capable of holding 20 standard 3-ton ingots or 16 5-ton slab ingots. This part of the installation is completed by six Stein and Atkinson recuperative cubicles, which are fired with mixed gas; and each of which is capable of holding six 3-ton or three 5-ton ingots. From this part of the works, the ingots pass to a cogging mill, the whole of the electrical equipment of which was supplied by the General Electric Company, Limited, Kingsway, London, W.C.2. This mill, a view of which is given in Fig. 1, has rolls with 42½-in. centres and a 9-ft. barrel and is designed to cog standard 3-ton ingots of 20-in. square section; or 5-ton slab ingots with a cross-section of 37½ in. by 19 in. The 3-ton ingots are reduced to 5½-in. square blooms in 19 passes, after which they are taken to a down-cutting Davy shears and then to a single-stand finishing mill, which has rolls of 36-in. centres and a 7-ft. barrel. The products of this mill are billets 2 in. to 5 in. square and slabs from 4 in. to 8 in. wide by 2 in. thick, which pass through an electrically-driven shear, where they are cut to the required length, before being pushed on to one of the four cooling beds.

ELECTRIC POWER SUPPLY.

Power for the main mill motor is obtained from a Ward Leonard Ilgner motor-generator set, a view of which appears in Fig. 2. This set includes a 3,000-h.p. slip-ring induction motor, which is connected to the 11-kV mains. It runs at about 735 r.p.m. and has a maximum operating peak output of 6,000 h.p. for 15 seconds. On the same shaft as the motor is a flywheel 9 ft. 6 in. in diameter and weighing 32¾ tons, which is designed to give up a total stored energy of 150,000 h.p. seconds. There are also three generators on the shaft, each of which has an output of 1,333 kW at 700 volts and a maximum operating peak output of 3,332 kW for 15 seconds. These three machines are normally connected in parallel, but change-over links are provided to enable any pair to be used for running the mill at reduced speed. All the machines have forced lubrication, and the bearings, with the exception of the two on the outside, are water-cooled. The flywheel runs in swivelled pedestal bearings, 13 in. in diameter and 27 in. long, which are also forced-lubricated, the supply of oil during normal operation being obtained from two geared oil pumps, which are belt-driven from the flywheel shaft. Two electrically-driven pumps are, however, provided for starting up and stand-by purposes. The cooling water is supplied by four pumps, which are driven by 5-h.p. 460-volt squirrel-cage induction motors running at 1,440 r.p.m.

The main motor, which is shown in Fig. 4, Plate XIX, is of the shunt-wound compensated type and has an output of 5,000 h.p. at ± 700 volts, with a working peak output of 12,500 h.p. at 50 r.p.m. and a maximum cutout peak output of 15,000 h.p. at the same speed. It is operated over a speed range of 0 to 50 r.p.m. by Ward Leonard control and from 50 to 100 r.p.m. by shunt control. It is equipped with two pedestal journal bearings, which are flow-lubricated from motor-driven oil pumps, the oil circuit incorporating a flow indicator with alarm contacts. A view of the armature is given in Fig. 5 and of the magnet frame in Fig. 6, on Plate XIX.

The Ilgner set, with the liquid starter and slip regulator for its motor, the main mill motor and the main switchboard and control desk are all housed in a motor room in which an air pressure of ½ in. water gauge is maintained by two fans. These fans are driven by 90-h.p. squirrel-cage induction motors at a speed of 730 r.p.m. and also supply cooling air to the machines.

EXCITATION PLANT.

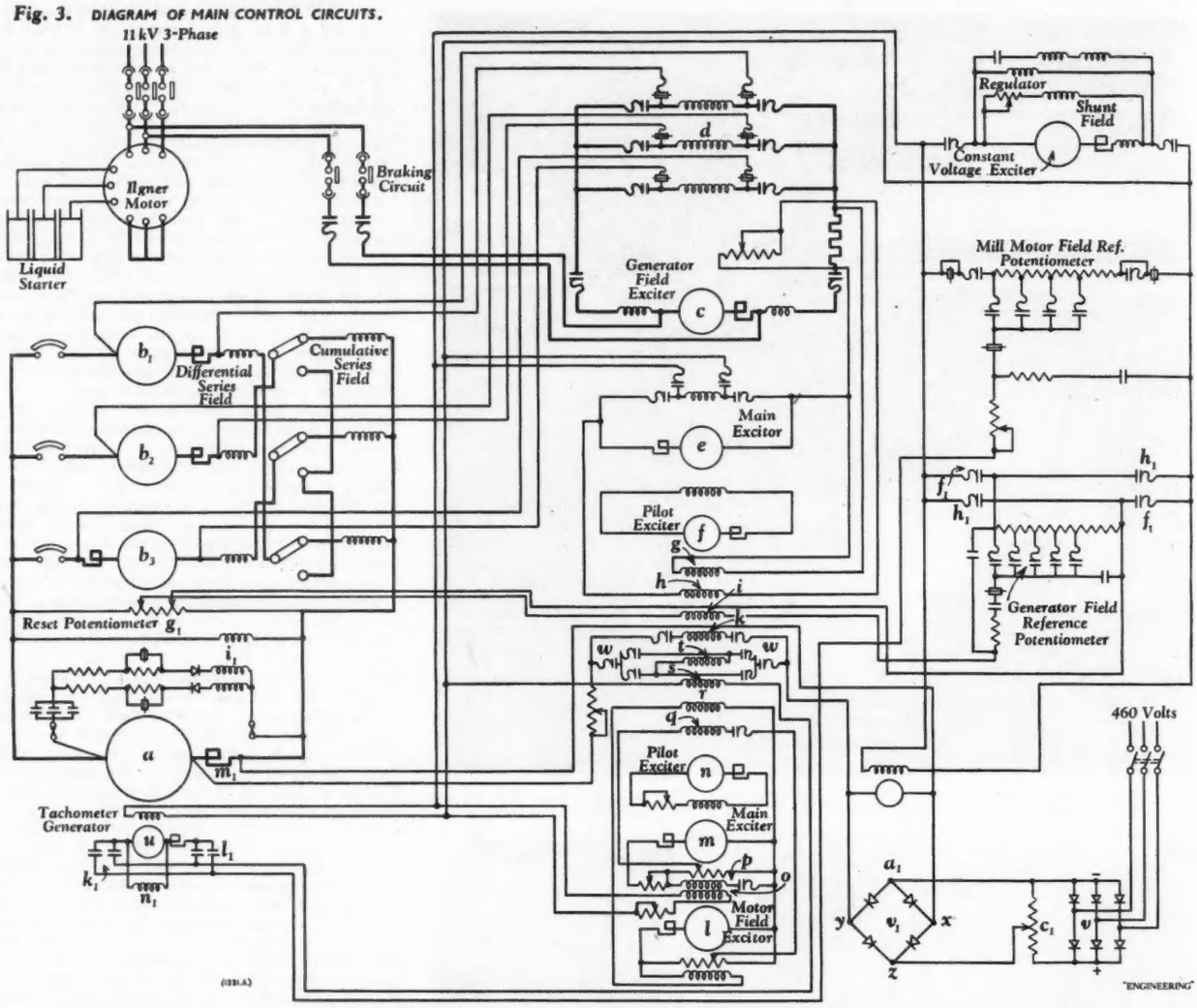
Four motor-generators, two of which provide excitation for the main drive, while two are associated with the direct-current supplies for the auxiliary drives, are housed in the basement of the motor room, as shown in Fig. 9, on page 635. One consists of a 140-h.p. 2,200-volt motor which runs at 970 r.p.m. and drives three generators, which supply the main-generator and mill-motor fields and the constant-voltage exciter. The other set consists of a 40-h.p. 460-volt motor running at 1,450 r.p.m., which drives the two main and two pilot exciters referred to below. In addition, the motor-generator supplying the auxiliary drives consists of a 575-h.p. 2,200-volt motor, which is connected to two 170-kW generators for the screw-downs and to a 44-kW generator for the breast roll. Finally, there is a screwdown cascade exciter set, which consists of a 40-h.p. 460-volt motor driving two screwdown generator exciters and two pilot exciters. The screwdown motors are of the standard steel-works type and are rated at 100/200 h.p., 230/460 volts, their speed range being 475 to 950 r.p.m. They are mounted on a platform above the cogging mill and are forced-ventilated from the main fans in the motor room. The breast-roll motors are also of the steel-works type and are rated at 25 h.p., 230 volts, at a speed of 1,300 r.p.m.

MAIN SWITCHBOARD.

The main switchboard controlling the direct-current and auxiliary alternating-current supplies is of the open flat-back type and is designed for remote operation from control desks in the motor room and in the mill pulpit. The motor-room desk, from which the mill motor-generator set, the screwdown and cascade exciter sets and all the auxiliary alternating-current drives are controlled, is illustrated in Fig. 8, Plate XIX, which also shows part of the main switchboard. Each starter is controlled by start and stop push-buttons with red and green indicator lamps; and sequence interlocking is provided. The desk is fitted with

ELECTRICALLY-DRIVEN 42½-IN. COGGING MILL.

Fig. 3. DIAGRAM OF MAIN CONTROL CIRCUITS.



a 5,000 h.p. mill motor.
b_1, b_2, b_3 Generators.
c Generator field exciter.
d "Suicide" contactors.
e Main generator exciter.
f Pilot generator exciter
g, *h*, *i* and *k* Pilot exciter field windings.
l Mill motor field exciter.
m Main motor exciter.
n Pilot motor exciter.
o and *p* Mill motor exciter field windings.
q, *r*, *s* and *t* Pilot motor exciter field windings.
u Tachometer generator.
v and v_1 Rectifiers.
w, k_1, i_1 and n_1 Relays.
x, *y*, *z* and a_1 Rectifier connections.
c_1 and g_1 Potentiometers.
f_1 and h_1 Contactors.
m_1 Mill motor field.

an annunciator panel on which any failure in the auxiliary alternating-current circuits is indicated. Audible warning is also given by a Klaxon horn. The mill will continue to run for a period of three minutes from the occurrence of such a fault to enable a newly-started ingot to be finished. At the end of this time, the whole mill is automatically shut down.

The main drive, screwdowns and breast rolls are controlled from the mill pulpit deck by cam-type reversing controllers. Similar controllers are provided for the ingoing and outgoing racks and the desk is also fitted with a speed indicator for the main drive and a position indicator for the screwdowns. A "stop" push-button, placed in the centre of the desk in a position convenient to both operators, enables the complete mill to be shut down in case of emergency. The liquid starter and slip regulator for the 3,000-h.p. induction motor of the main motor-generator set are shown in Fig. 7, Plate XIX. The moving and fixed electrodes of this regulator are phosphor-bronze grids operating in rubber-lined steel pots, which are entirely immersed in solution. In the full-on position the electrodes are prevented from making contact with each other, the amount of resistance left in circuit being such that the slip is limited to 10 per cent. at the full-load torque of the motor. The electrolyte is circulated by a 1½-h.p. pump, and the starter itself is operated by a direct-current motor fitted with limit switches and interlocking contacts.

Control System.

The cascade system, which is used in conjunction with the Ward Leonard system for controlling the fields of the generators supplying the main and screwdown motors, is designed so that the excitation of a large generator can be varied and, if necessary, reversed in a very short time with the expenditure of a small amount of energy in the initiating circuit. To change or reverse a large field quickly an exciter giving a maximum voltage of up to six times the normal field voltage is required; and it is also necessary for such a machine to have appreciable power in its own field circuit. By using a pilot exciter to provide the excitation of the main exciter the power required to initiate a change in the main generator field is reduced, while if this pilot exciter is also designed to give a far higher voltage than is normally required a rapid response is obtained. To ensure this rapid response both exciters must have completely laminated iron circuits. Apart from this, however, and the provision of two additional field windings on the pilot exciter to prevent hunting, they are standard direct-current machines.

Hunting is prevented by connecting one of the additional windings across the output of the main exciter and the other in series with the armature of the same machine. Under steady conditions the magnetising forces in these two windings neutralise each other, and there is no resultant effect on the field. When the current in the main generator field is changing, however, the pilot fields are unbalanced by the inductance of the generator field and an extra magnetising force is applied to the exciter field. To control the main mill motor, the armature of which weighs 58 tons, three exciters connected in cascade are employed, thus enabling the change from full speed forward to full speed reverse to be effected in 5⅓ seconds, and from base speed forward to base speed reverse in 2 seconds.

Control Circuits.

A diagram of the main control circuits is given in Fig. 3, from which it will be seen that the 5,000-h.p. mill motor *a* is connected in a closed loop circuit containing the three generators b_1, b_2, b_3, and that the fields of these generators, which are connected in parallel, are energised from the generator field exciter *c* through the "suicide" contactors *d*. When the machines are at rest these contactors connect the field windings to the armatures of the generators, thus preventing circulating currents and "creeping."

The generator field exciter *c* is excited from the main exciter *e* and the latter in turn is excited from

ELECTRICALLY-DRIVEN 42½-IN. COGGING MILL.

(*For Description, see Page* 633.)

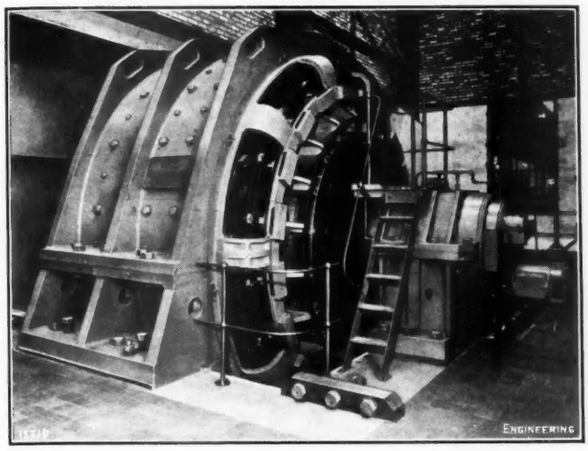


FIG. 4. 5,000-H.P. COGGING-MILL MOTOR.

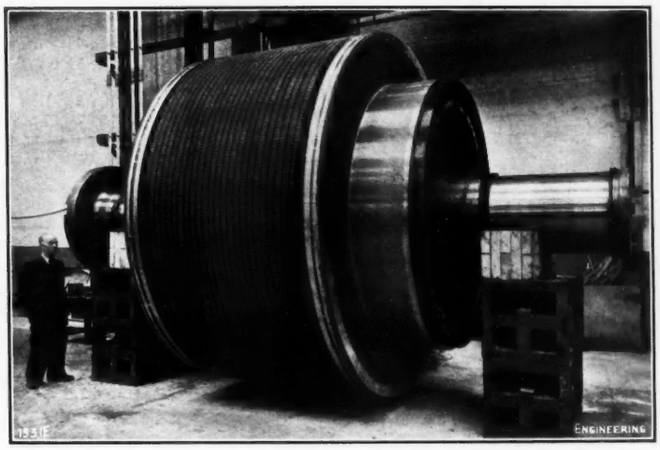


FIG. 5. ARMATURE OF 5,000-H.P. MOTOR.

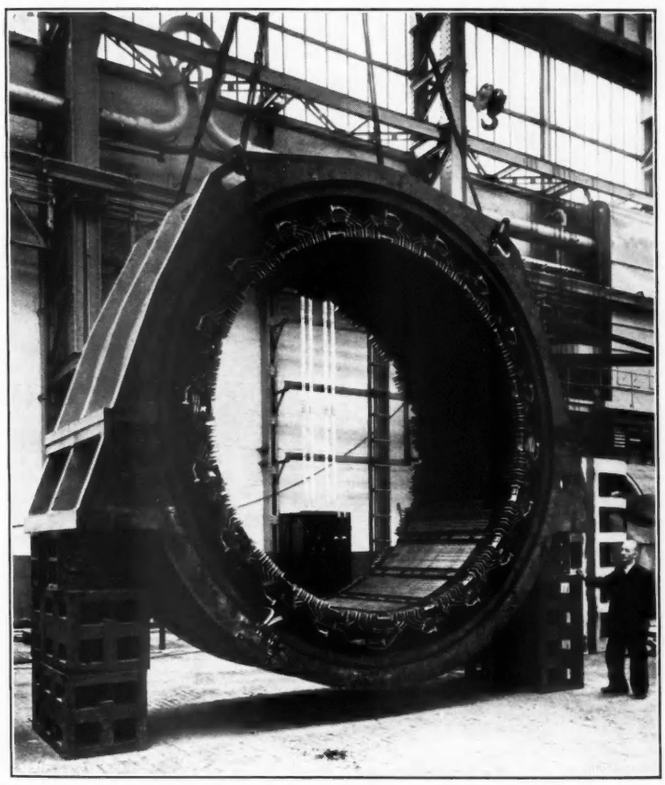


FIG. 6. MAGNET FRAME OF 5,000-H.P. MOTOR.

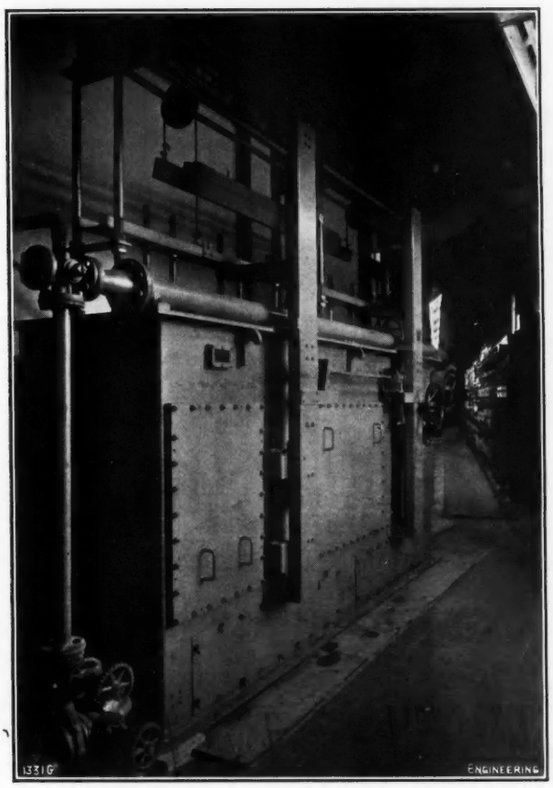


FIG. 7. LIQUID STARTER AND SLIP REGULATOR.

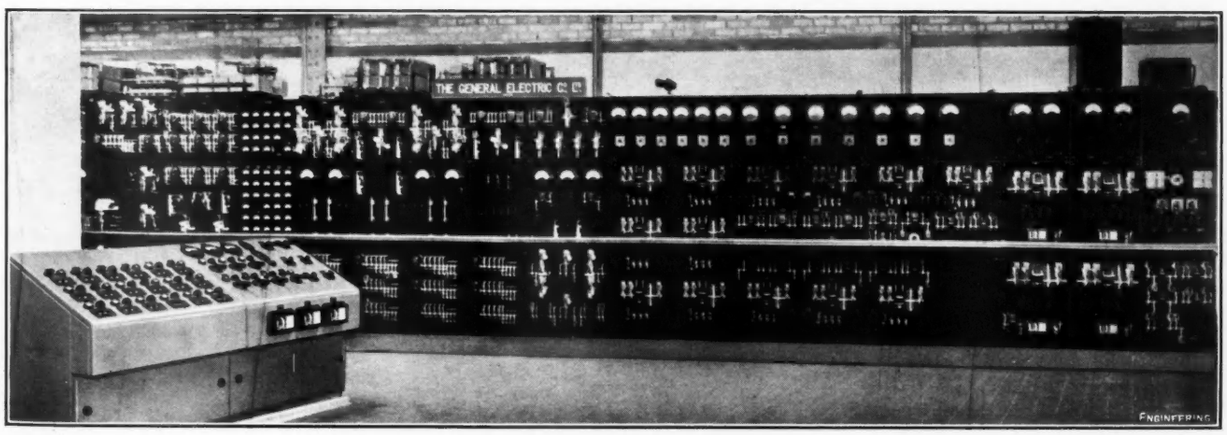


FIG. 8. CONTROL DESK AND SWITCHBOARD.

(*To face page* 634.)

ELECTRICALLY-DRIVEN COGGING MILL.

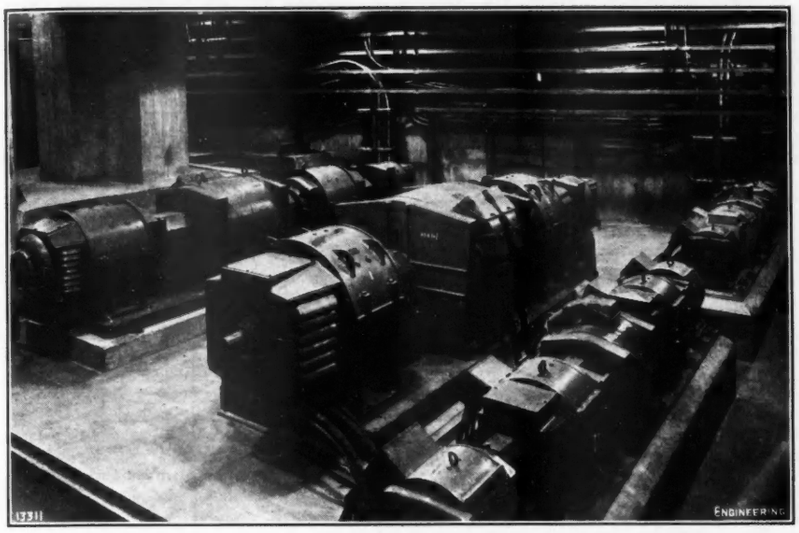


FIG. 9. MOTOR-GENERATOR AND CASCADE EXCITERS.

the pilot exciter *f*. The latter machine has four field windings, *g*, *h*, *i* and *k*, of which *g* and *h* receive current and voltage signals from the succeeding stages of the cascade system and thus stabilise it. The control winding *i* receives a voltage which is the difference between a reference voltage selected by the master controller and a suitable fraction of the generator voltage. At steady speeds the small difference between these two voltages is sufficient to produce the required generator excitation. Winding *k* in Fig. 3 opposes or resists winding *i* when rapid changes, which would otherwise cause excessive currents in the main loop circuits, take place in the reference voltage.

The mill motor *a* is excited by a motor field exciter *l*, which is itself excited by a main field exciter *m*. The latter is in turn excited by a pilot exciter *n*. Exciter *m* has two field windings, *o* and *p*, of which *o* provides the maximum field current required for the main motor. Winding *p* is excited by the exciter *m* and opposes winding *o* to provide the reduction in the main motor field, which is required to set up the maximum speed and also the "forcing" necessary to ensure rapid response to a control signal.

Pilot exciter *n* also has four field windings, *q*, *r*, *s*, *t*. Of these, *q* and *r* are stabilising windings and *s* receives the difference between a reference voltage selected by the master controller (not shown in the diagram) and the voltage received from a tacho-meter generator *u*. At steady speed the small difference between these voltages is sufficient to reduce the excitation of the exciter *l*, and hence of the motor *a*, to the value required by the position of the master controller. Winding *t* is arranged to provide a current-limiting feature, which is similar to that produced by winding *k* on the pilot exciter *f*, as described in detail below.

The rectifier systems, *v* and v_1, in conjunction with the current-limiting selector *w* and windings *k* and *t* on the pilot exciters limit the maximum current passing in the main loop circuit in the following way. Below the basic speed of 50 r.p.m. the windings *k* and *t* are connected in series with the main motor compound winding and compensation windings to the points *x* and *y* on the rectifier v_1. The points *z* and a_1 on this rectifier are supplied with an adjustable voltage from the potentiometer c_1, which is energised by rectifier *v*. So long as the voltage across *z* and a_1 exceeds the voltage drop across m_1 no current passes through winding *k*. If, however, the main loop current increases until the voltage across m_1 exceeds that across za_1, a current will pass through *k* and this current will oppose any change in *i*. Thus, when the master controller is moved rapidly from "zero" to "basic speed," the generator excitation will be increased until the current in the loop exceeds the limit set by the voltage across $z\,a_1$. Any further increase in the pilot voltage will, however, be checked until the acceleration of the motor causes a fall in the line current, and this sequence will continue until the basic speed is reached. During retardation the main loop current controls the rate of fall of the voltage of the pilot exciter *f* in a similar manner. During acceleration above the basic speed, the current limit is transferred by relay *w* to exciter *n*, where it acts in a similar manner, but in the opposite sense, the generator meanwhile producing its full voltage.

OPERATING CONDITIONS.

As regards operation, moving the master controller from "stop" to "basic speed forward" closes contactor f_1, thus energising the generator-field reference potentiometer for forward running, so that the full reference voltage is applied to the field winding *i*. The voltage of the pilot exciter *f* then rises rapidly and excites the exciters *e* and *l* and the generator fields in turn. The generator voltage is thus caused to rise rapidly and a heavy current is built up in the main loop circuit, so that the voltage drop across m_1 exceeds the reference voltage from the rectifier *v*. A current proportional to this excess will circulate through *k*, thus keeping the loop current to the limit set by *v*. The mill motor will then accelerate rapidly to basic speed. At this point the loop current will fall, the current in *k* will be zero and the mill motor will run steadily at basic speed. A similar sequence will take place if the master controller is moved to "basic speed reverse," except that contactor h_1 instead of contactor f_1, will close, thus reversing the reference voltage.

The mill is brought from basic speed to stop by moving the master controller to the stop position. Contactor f_1 is therefore opened and field *i* is directly connected to the re-set potentiometer g_1. As a result, the voltage of the exciters *e*, *f* and *l*, and the generators, is rapidly reduced so that the mill motor regenerates and feeds a large current into the loop circuit. As soon as the voltage drop across m_1 exceeds the reference voltage from the rectifier *v*, a current will pass through *k* in a direction opposite to that during acceleration. This current will oppose the voltage from the potentiometer g_1, so that the generator voltage is maintained and the regenerated current is limited to a pre-set figure. Finally, the falling generator voltage will release the relay k_1 and the latter, in turn, will open the "suicide" contactors *d*.

In running the mill up from stop to full speed, acceleration up to basic speed takes place, as described above. Relay k_1 then closes and, in turn, closes relay l_1, thus selecting the correct polarity on the tacho-generator *u* for forward running and closing relay *w*. The current limit is thus transferred from pilot exciter *f* to pilot exciter *n* and the circuit of exciter field *s* is closed. The latter now receives a voltage proportional to the difference between the voltage from the motor field potentiometer and the output of the tacho-generator. Field *s*, by acting in opposition to field *t*, weakens the motor excitation, thus causing a rapid rise in the current in the main loop circuit, and bringing the current-limit feature described above into operation.

To bring the mill from full speed forward to stop, the master controller is moved to "stop." Both the generator-field reference potentiometer and the mill-motor field reference potentiometer are thus disconnected and the contactor f_1 is held closed, so that the full reference voltage is maintained for generator control. The motor reference voltage is meanwhile reduced to zero and the tachometer *u* is short-circuited through the field *s* of the pilot exciter *n*. The result is that the maximum "lower speed" signal is given to the motor exciter system, and the motor field is strengthened at a rate controlled by the current-limiting device. When the mill reaches basic speed, the relay n_1 opens so that l_1 and *w* are, in turn opened and field *i* is re-connected to its reference potentiometer, which is in the zero position. The maximum "lower voltage" signal is given to field *i*, so that it is rapidly weakened by the current-limit control, which has been restored by the opening of *w*. Finally, at low voltage, the contactor *d* makes a suicide connection under the control of voltage relay k_1.

When it is required to change the mill from full speed forward to full speed reverse, contacts on the master controller disconnect exciter field *s* from the reference potentiometer and, by short-circuiting the tacho-generator through this field, cause the maximum "lower speed" signal to be given to exciter *n*. The motor field is thus rapidly strengthened under current-limit control. The generator field is unaffected until relay l_1 opens at basic speed and, in turn, opens relay l_1. Contacts h_1 are then closed, thus reversing the reference potentiometer. A limiting resistance is introduced into the reference circuit to avoid an unduly heavy signal to exciter field *i*. This field receives the maximum lower speed signal and rapidly reduces the exciter voltage under current limit control. Acceleration in the reverse direction then takes place, as previously described.

ELECTRIC TRACTION IN BELGIUM.

WORK has now been started on the conversion of the railway line between Brussels and Liège to electric traction. Power for operation will be obtained from the national electricity supply network through four substations at Brussels-Nord, Louvain, Landen and Bierset-Awans. Of these, the first will be supplied at 36 kV and the high-tension equipment will be installed indoors, while the supply voltage at the other three will be 70 kV and outdoor equipment will be used. The high-tension supplies will be converted for traction purposes into direct-current at 3,300 volts in 3,000-kW transformer-rectifier groups, three of which will be installed in the Brussels, Louvain and Bierset-Awans substations and two at Landen. Arrangements have, however, been made for a fourth group to be subsequently installed at both Brussels and Louvain. The Brussels substation will be arranged to supply the lines to Antwerp, Namur and Ghent as well as that to Liége, while the Louvain substation will also feed the lines to Malines and Ottignies, and that at Bierset-Awans the line to Kinkempois. Sectioning posts are to be built at Kortenberg, Tirlemont, Waremme and Liége.

SHORT SA/4 BOMBER AIRCRAFT.—The second prototype SA/4 long-range high-altitude bomber aeroplane, constructed by Short Brothers and Harland, Ltd., Queen's Island, Belfast, Northern Ireland, has been delivered to the Ministry of Supply to undertake a programme of development trials on military equipment. The SA/4, it may be recalled, has four Rolls-Royce Avon jet engines arranged in vertical pairs in wing nacelles.

LARGE DRY DOCKS.*

By E. LESLIE CHAMPNESS, M.B.E., M.Sc.

THE two large dry docks at Sydney and Capetown were discussed in papers read before the Institution of Civil Engineers early in 1948, following which a special Dry Docks Committee, under the chairmanship of Mr. M. G. J. McHaffie, was initiated by that Institution, charged with reviewing the design and equipment of dry docks. By request, the Institution of Naval Architects appointed two representatives—Mr. G. McL. Paterson and the present author—to represent the naval architectural point of view, and to give assistance on the main committee and on various panels, together with many experts experienced in civil engineering and mechanical equipment connected with dry docks, cranes, pumps, etc. The results of their deliberations were published by the Institution of Civil Engineers in 1952 as *Dry Docks—Memorandum on Construction and Equipment*.

The Admiralty point of view was taken care of by direct representation on this committee of the Director of Naval Construction and the Dockyard and Civil Engineering Departments; their requirements and resources differ to some extent from those of private docks, though inevitably, in times of emergency, the Admiralty becomes a major user of private facilities. No doubt this *Memorandum* will be studied in detail by those contemplating building new dry docks and by the various experts who carry out such projects. At any rate, the numerous headings of almost everything concerned, and the merits or demerits of alternative equipment, were very fully discussed, though little of this appears in the *Memorandum*, which, under the terms of reference, restricts itself to summarising the conclusions reached.

Not all of this is much more than of general interest to those who are the users of dry docks, who are chiefly concerned in getting the most efficient service they can, nor to all dry-dock owners, though much of it will amply repay study by them; and if they are private dry-dock owners they will doubtless weigh up the commercial return or necessity for all the items dealt with in this comprehensive survey. Much depends on the demand and type of work undertaken by particular private establishments, and the diversity and incidence of this colours the individual requirements and necessities of private firms. Opinions and experience naturally vary, but almost all aspects are covered by this *Memorandum* and much valuable information is at the disposal of the private dry-dock owner contemplating expansion.

The notes initially given to this committee in April, 1948, as representing the naval-architecture point of view, on the particular questions of proportions of length to beam, naval requirements of the future and dock proportions and facilities, are given below. No events have occurred since then, within the author's knowledge, to change these opinions.

TREND OF PROPORTIONS OF LENGTH TO BEAM.

In an examination of a number of large merchant and passenger liners for proportion of length to beam, it will be found that—irrespective of their particular service (i.e., Atlantic, Pacific or Europe—Far East, via Suez or Panama), they range from Beam $= \frac{L}{10} + 5$ ft. to $\frac{L}{10} + 21$ ft., where L = length overall in feet. The beam of present-day vessels tends towards the upper limit. Certain special classes of large merchant vessels, 500 ft. to 700 ft. in length, such as whale factories, oil tankers, and ore vessels, are generally of the $\frac{L}{10}$ + 20 ft. type, and some have slightly greater beam. Some types of naval auxiliary vessels, such as depot ships and fleet repair ships, also rise to similar proportions.

From the purely naval-architecture design point of view, the natural expansion over the years of passenger and cargo vessels for minimum transportation costs would be by increase of draught (see "The Draught and Dimensions of the Most Economical Ship," by Sir John Biles, *Trans. I.N.A.*, 1931). In fact, the draught of the largest ships is still limited more by dry-dock availability than by the depth of major canals, dredged channels or other terminal facilities, so that the normal developments in the period 1910-1948 have increased liner dimensions from 700 ft. to over 1,000 ft. in length; but corresponding increase in load draught has only risen from 35 ft. to about 40 ft. Designers are thus still driven to length and beam as the only possible expansion directions, owing to these world limits of depth of water.

This tendency to increased beam proportions in passenger liners, over the past 40 years, is due chiefly to the increased top hamper from the original modest type to present luxury types, and, since this has now reached a probable maximum, it is unlikely that any corresponding increase will take place in the future. Light-alloy material is also now available and is likely to be used increasingly for superstructures, boats, etc., which will not necessitate increase of beam for stability purposes. The proportions of docks proposed in Fig. 1, herewith, should not be overtaken in the future, therefore, by developments in ship proportions such as have occurred over the past 40 years, which have already caused many dry docks to be relatively too narrow to-day. The curve of dry-dock width in the upper part of Fig. 1 is the curve of ideal width suggested; the curve of width in the lower part is 10 ft. less.

NAVAL REQUIREMENTS OF THE FUTURE.

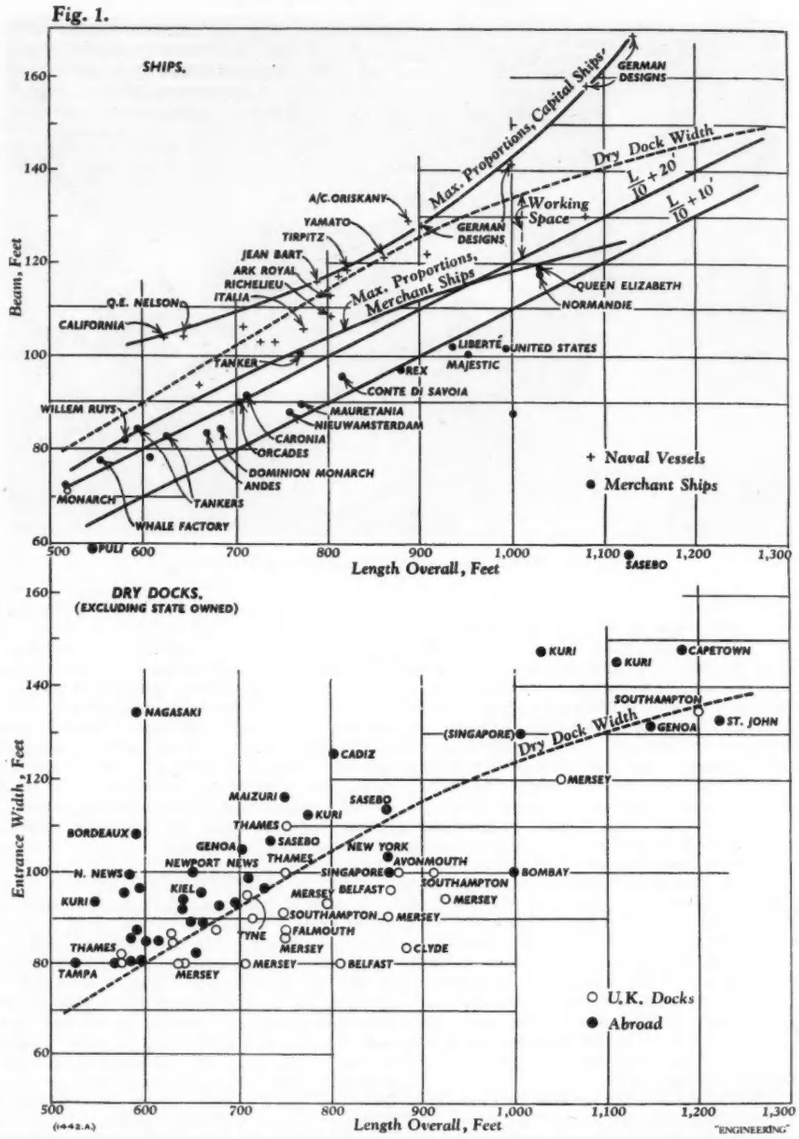
As the age of assured world peace and abolition of armaments still seems to be a long way off, requirements for all dry docks must still take cognisance of naval requirements, since, as always, civil docks must be used in assisting State dockyards in national emergencies. The past tendencies in naval design in the pre-atomic period, up to 1944, show the same trend as for all other vessels, namely, steady and progressive increase in size, though generally with extreme beam characteristics. The largest key vessels setting the pace for dry docks (or perhaps more correctly, of which the dimensions have been limited by existing or projected dry docks) were battleships and aircraft carriers.

The latest published information as to the tendency and size of battleships in the pre-atomic era is probably that given by Commodore Schade, U.S.N. (*Trans. Soc. of Mar. Eng. and Naval Arch.*, New York, 1946) on "German Wartime Technical Developments." This quotes the developments of the German "H" type of battleship, one of which was laid down by Blohm und Voss at Hamburg in

* Paper presented at the Spring Meeting of the Institution of Naval Architects, held in London, March 25 to 27, 1953. Abridged.

LARGE DRY DOCKS.

Fig. 1.



1939 but was never completed. The design was under continuous review on paper by the German naval authorities and increase in size and proportions was made as follows :—

Length.	Beam.	Draught.	Date.
Ft.	Ft.	Ft. in.	
910	122	33 0	1939 as laid down
902	128	40 0	— as laid down— "H" '41 design
1,000	141	—	1942 "H" '42 design
1,082	158	42 3	1942 "H" design
1,132	169	44 3	1944 "H" design

For these vessels Germany constructed three dry docks at Hamburg, Bremen, and Wilhelmshaven—now all destroyed—which were 1,020 ft. to 1,140 ft. by 197 ft.

As far as very large capital ships with normal pre-atom armament are concerned, the tendency appears to be for beam proportions to extend very rapidly, requiring dry docks of extreme breadth, which would be uneconomical for ordinary normal requirements. These vessels and the large capital ships (see Dr. Oscar Parkes, *Trans. I.N.A.*, 1949) and the present United States aircraft carrier policy represent so far the upper limits.

There is as yet no information, nor any actual building of new vessels, which indicate the probable tendencies of naval construction embodying the results of the observations of the 1946 Bikini and later atomic bomb experiments or radar developments, except in smaller craft for submarine detection and offence. General naval and technical opinion indicates that the existence of such weapons, though they may change the character of naval fighting units, will not see the end of seaborne navies, either for offence or commerce protection. The atomic bomb, and other offensive weapons developed from it, in conjunction with rocket and/or jet-propelled direct or guided missiles will alter considerably the offensive weapons carried and the type of protection required against them.

This protection, both against blast, heat, and under-water bursts, would seem to indicate that size would develop in much the same manner as with existing conventional weapons of the past. Indeed, the tendency to present a small surface, under and above water, to shock transmission may limit draught and increase beam in much the same manner as at present. It may well be, however, that the fleet of the future may consist of smaller units, more readily dispersable and, except for action, not necessarily to be habitable in the manner of the past and present naval vessel. Personnel may be borne normally in fast mobile parent vessels, similarly dispersable, the size and type of which are as yet undeveloped.

Since this matter of naval tendencies concerns only the docking facilities for very large types of capital ships, and such large projects as super dry docks will not be lightly entered upon in present days of high cost levels, it is probable that the trend will be clearer before any such enterprise is begun. Whatever the size or proportion of a dry dock, the position eventually arises where it docks a "shoe-horn" case of the maximum size of vessel which it can accommodate. If this case happens to be an aircraft carrier of the present relatively standardised type—that is, with offset bridge structure and gun sponsons clear of the flying deck—these projections, both in the state of high water level when docking and at the level docked down on the blocks, indicate the desirability of dock-side crane structures, high lighting standards, etc., being kept approximately 25 ft. clear of the maximum beam line, though this necessarily increases the length of any crane jibs which are required to be able to plumb the centre of the dock.

TABLE I.—NUMBER OF DOCKS AVAILABLE.

Entrance width	Dry Docks.			Floating Docks.			Total.		
	80 ft. and over.	90 ft. and over.	100 ft. and over.	80 ft. and over.	90 ft. and over.	100 ft. and over.	80 ft. and over.	90 ft. and over.	100 ft. and over.
Mercantile dry docks :									
Public and private—									
U.S.A.—									
Atlantic	8	4	1	38	18	4	46	22	5
Pacific	7	1	1	18	13	1	25	14	2
Total	15	5	2	56	31	5	71	36	7
Great Britain—									
Public	15	10	6	—	—	—	—	—	—
Private	10	3	—	—	—	—	25	13	6
Total	25	13	6	—	—	—	25	13	6
South Africa	3	2	2	—	—	—	3	2	2
Canada—									
Atlantic	1	1	1	2	2	2	3	3	3
Pacific	—	—	—	3	3	1	3	3	1
Australia and New Zealand	2	—	—	1	—	—	3	—	—
Other Commonwealth	3	2	1	—	—	—	3	2	1
Japan	20	17	9	1	—	—	21	17	9
Italy	5	5	3	—	—	—	5	5	3
Holland	1	—	—	8	6	4	9	6	4
Germany	5	2	—	4	3	2	9	5	2
France	5	4	3	4	—	—	9	4	3
Sweden	3	—	—	5	1	—	8	1	—
Belgium	3	1	—	—	—	—	3	1	—
Spain	3	2	1	—	—	—	3	2	1
Other countries	8	1	1	3	3	3	11	4	4
Total	102	55	29	87	49	17	189	104	46
State-owned dry docks :									
U.S.A.—									
Atlantic	19	16	10	—	—	—	19	16	10
Pacific	20	17	12	1	—	—	21	17	12
Total	39	33	22	1	—	—	40	33	22
Great Britain—									
Home dockyards	14	12	8	1	1	1	15	13	9
Foreign and Commonwealth	13	11	5	3	2	2	16	13	7
Total	27	23	13	4	3	3	31	26	16
France and Colonies	18	16	11	—	—	—	18	16	11
Italy	6	6	5	2	2	1	8	8	6
U.S.S.R.	4	3	1	1	1	1	5	4	2
Other countries	5	4	3	1	1	1	6	5	4
Total State	99	85	55	9	7	6	108	92	61
Total public and private	102	55	29	87	49	17	189	104	46
World total all docks	201	140	84	96	56	23	297	196	107

TABLE II.—WORLD TONNAGE : 30 YEARS' INCREASE IN BEAM (MERCANTILE PASSENGER OR CARGO VESSELS AND TANKERS.)

—	Gross Tonnage, Over 70 Ft. Beam.	Number of Vessels 70 Ft. Beam and Over.	Number of Vessels.			
			Over 70 Ft. Beam and Under 80 Ft.	Over 80 Ft. Beam and Under 90 Ft.	Over 90 Ft. Beam and Under 100 Ft.	100 Ft. Beam and Over.
1924*	1,579,502	80	70	5	3	2
1952 (October)*	7,973,739	510	376	123	7	4
1954 (estimated)	9,750,000	663	500	150	9	4

* By courtesy of Lloyd's Register of Shipping.

SUGGESTED DOCK PROPORTIONS.

The upper part of Fig. 1 indicates the proportion of a number of past and present large merchant and war vessels, with enveloping curves of maximum proportion of length to beam. From the merchant-ship point of view, this gives rise to a curve of dry-dock width on a basis of length overall allowing suitable clearance for repairs. Vessels of smaller length, with out-of-proportion beam, can generally be accommodated in dry docks (of which there are probably a large number) up to 100 ft. longer than the vessel itself, and this applies to vessels such as naval monitors and Maracaibo types of oil tankers.

The lower part of Fig. 1, on the same basis, indicates the overall length and average entrance width of large docks in this country and abroad. The fact that all but about six of the existing United Kingdom mercantile dry docks lie below the line of ideal entrance width for present-day lengths, whereas over 50 dry docks abroad, apart from floating docks, lie above this curve, indicates the extent to which many United Kingdom docks are now out-of-proportion with modern trends.

The extent of modern services necessary, and provided in many cases in those large private dry docks which cater for long-term repair jobs, and frequently call for maintenance of officers and crew living on board, are not always realised—particularly when compared with many public dry docks, which are mainly occupied by quick turn-round jobs, painting, etc., and stern-gear work only, as happens in some terminal ports. These services may be listed shortly, apart from the shops which serve every shipyard trade, as :—

Pumping and drainage.

Cranage—dockside—for quick light lifts and slower heavy machinery at large radius, reaching the centreline of wide docks.

Salt water ; fire, tank-testing, magazine-flooding.

Fresh water ; ship supplies, wet sandblasting, sprinkler system coupling.

Frost precautions to water systems.

Compressed air ; working tools ; sand or grit blasting ; plastic painting, hot and cold.

Sewage disposal (occupied ships) ; sewage mains and branch connections.

Shore facilities ; canteen and galley ; sanitary and wash places ; fire patrols ; hostels.

Telephones—for use of personnel remaining on board ; fire alarms, etc.

Electric light and power ; domestic use, light, heat, etc. ; working tools, welding, earthing, flood-lighting dock area and in dock ; temporary wandering leads.

Steam : heating, coupling to ships fire pumps; sand-blasting, oil and sludge heating.

Oxy-acetylene mains ; burning away.

Oil-fuel storage and settling tanks ; transfer line ; sludge disposal.

Lifts to dock bottom ; personnel and material.

Loudhailers.

Extensive staging ; trestles, blocking, shoring and supporting gear for damaged structures, keel-block cradles and storage for same.

Handling gear ; capstans, bollards, fairleads, leading-in gear, etc. ; Diesel tractor tugs for block line adjustment work in dock bottoms, etc.

Hydraulic power.

Modern repair facilities require in addition ample quay spaces similarly equipped for work afloat, which are, in fact, practically one-sided docks. Vessels drawing as much as 42 ft. of water afloat, damaged from war causes, or loaded ships, may also occasionally be accommodated. The thickness of dock bottom is an important factor in these cases and for other repair cases of special loading.

General Position.

Apart from the deliberations of the Dry Docks Committee, it has been apparent for some time that there is an increasing pressure on large docks to-day, particularly in the United Kingdom, and it is a matter of some concern to those interested. Mr. Basil Sanderson (*Trans. I.N.A.*, 1952, page 186) refers to this and quotes the corresponding increased fuel costs to owners. Commercially, the dominating and governing factor to-day is the constant development of the oil tanker, which, as she ages, necessarily involves rather more extensive upkeep repairs and steel-working facilities than those required for large ocean liners at fixed terminal ports. By their numbers, these tankers form the major user of large facilities. It is therefore not inopportune to examine the position as to the trend of events in some detail.

Fig. 2, herewith, indicates the approximate proportions of modern tankers over 20,000 tons deadweight and the number of United Kingdom dry docks capable of accommodating the various sizes, which rapidly decreases with size; indeed, the largest tankers now building and projected exceed the limits of British private docks available with repairing services.

In the following rough analysis from published information, from Appendix III of Lloyd's Register of Shipping (1952), relating to existing effective dry docks, etc., dry docks 540 ft. in length and marine railways, slipways and floating docks under 8,000 tons lifting power have been ignored.

The lower limit of 80 ft. beam in Table I, page 637, represents oil tankers of approximately 26,000 tons deadweight, and passenger ships of about 22,000 gross registered tons. State-owned docks are not available to merchant ships generally, except in emergencies, and many public docks, particularly those in terminal ports with liner traffic and commitments, are not generally available for long-term repairs. This position as to private dry docks has remained practically stagnant for many years in spite of the increasing size of merchant ships, and the long memories of the years of depression still seem to colour the situation. The growth of demand for larger sizes has not remained constant, however, and is indicated roughly by Table II, page 637.

In considering Table II, which has been taken down to 70 ft. beam, allowance should be made for the working space necessary round ships under repair, when comparing the numbers of docks available as per Table I. The growth of numbers in the 80-90 ft. beam class is notable. These vessels, being total world tonnage, do not all trade to Britain, but reflect the general increase in beam; but the figures for British-owned tonnage show equivalent increases.

In relation to its mercantile shipowning interests, the declining position of the United Kingdom, in failing to keep pace with increasing size in private and public docks, is significant. There is a probable deficiency in the number of dry docks for merchant ships in this country, not only in the larger ranges, but certainly for all sizes of ships over 65 ft. beam, which need a working width of about 75 ft. or more for repairs; and the growth in numbers of these vessels in the last 30 years, with an almost unchanged United Kingdom dry-dock position, is very considerable, i.e., probably about ten times. Two or three years at least are required for the construction of a large dock at present, so that this is a matter that cannot be suddenly righted.

This country is not a large user of floating docks, and one of the chief reasons is that, apart from life and maintenance and vulnerability, the depth of water available is not generally sufficient on the rivers and estuaries where the major repairing facilities and manpower are available. Vulnerability is, in fact, a relatively small detail matter in mercantile dry docks, and concerns chiefly the armouring of gates and dispersal of pumping facilities. As obsolescence, all over the world, overtakes the older dry docks, outmoding them particularly in beam, replacement costs must force dock dues into line with this world of changed values. The large number of medium-size docks available may delay this in their case—but it is on the large-size dock that the greatest pressure and demand will come. In all extensions to and construction of large-size docks, i.e., the expansion of the industry to meet modern trends, the problem is urgent.

These uncertainties are aggravated by the withdrawal, in the 1951 Budget, of the initial allowances for depreciation, and there is naturally a strong feeling that enterprise, embarked upon under given and stated conditions of relief, should be at the mercy of sudden changes in financial policy which completely undermine the stability of projects of this character. These are in the national interest and have previously required courageous decision in the light of present-day conditions. The need for reduced State expenditure and consequent reduced taxation are with us in all walks of life, but until and unless this can be achieved some other relief is necessary. It is also vitally necessary to the industry that more adequate depreciation allowances within shorter periods should be granted if any future expansion is to take place.

Unlike a ship or plant, an obsolete dry dock generally is a liability and has no residual value. The position of the dock owner, therefore, is worse in this respect than many other forms of business. This position reflects the discouragement of necessary enterprise and the urgent necessity for a system of non-penal taxation, which ceases to bleed industry of its powers of replacement and expansion, but spreads obsolescence. This is a political matter of first-class importance to this country, particularly at the present time. Discrimination in taxation between industry and industry is not a popular thought, but in this wider issue and background of security, in which shipping and those interests which serve it are bound up, we may have to revise our thoughts if we are to avoid stagnation and if there be no other means of relief. Those who have been through two World Wars need no warning of the serious effect of unpreparedness in emergency.

LARGE DRY DOCKS.

Fig. 2.

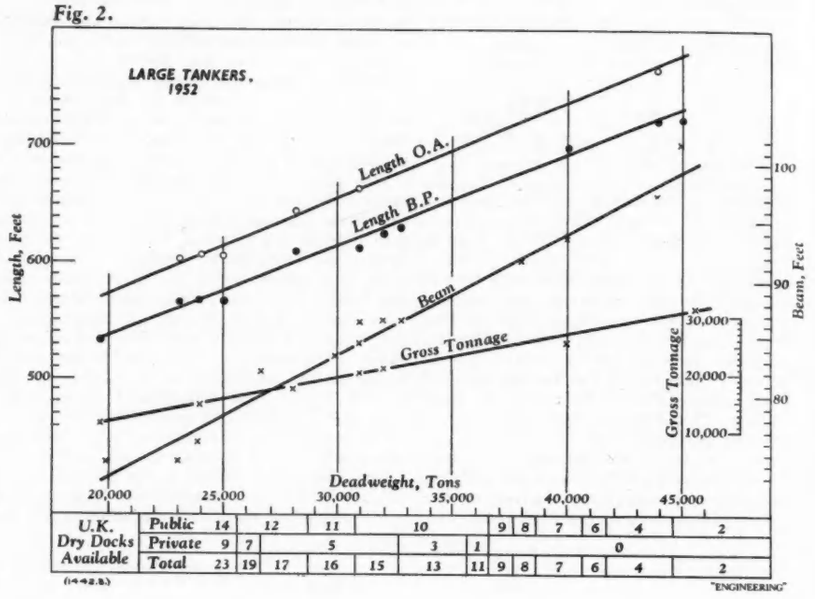
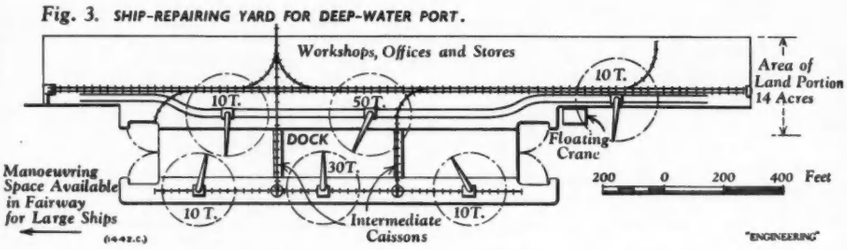


Fig. 3. SHIP-REPAIRING YARD FOR DEEP-WATER PORT.



Economic Considerations of Present-Day Expansion.

Even with an existing organisation, land and ancillary shops and services, the cost of a dock of 700 ft. to 900 ft. at to-day's level will vary from 1*l.* million to 2*l.* millions, depending on dimensions and local circumstances, and the extent of ancillary shops and services provided. Where a major project has to be laid down on virgin ground with reclamation work and completely new facilities, such as the Garden Island project and the Captain Cook Dock at Sydney—(1,133 ft. × 140 ft., built in 1941-45), the cost was approximately 8*l.* millions, and in the Sturrock Dock installation at Capetown (1,181 ft. × 148 ft., 1943-45) the dry dock itself cost 3½*l.* millions, excluding the prior reclamation work. This expenditure, necessary as it was for strategic reasons, is beyond the commercial sphere where, in private enterprise, there is a necessity for adequate return for capital expenditure.

A dry dock continuously full with large tankers of 37,000 tons deadweight, with an approximate gross tonnage of 25,000, for every working day of the year allowing a six-day week (instead of five days and holidays) would earn a total return in dry-dock dues at existing rates of 90,000*l.* per annum gross, against which the upkeep and working costs must be charged to arrive at a net return. The premises of full and capacity occupation and full use of time are, of course, impossible to achieve in practice and the probable return, even in to-day's busy

PRODUCTION PRESS BRAKE.

F. J. EDWARDS, LTD., LONDON.

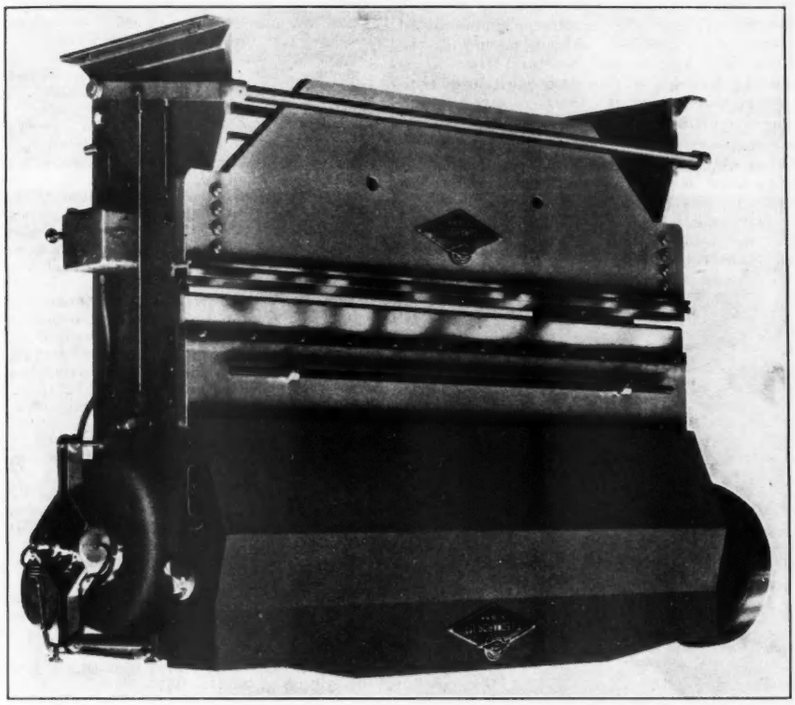


FIG. 1.

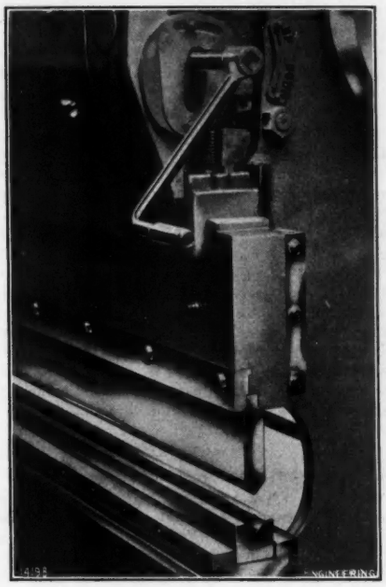


FIG. 2.

time, would be more likely to be about 35,000*l.* per annum net.

This return, even upon capital expenditure as low as 1*l.* million, apart from the depreciation factor, would scarcely justify the enterprise by itself, and one would have to rely on attracting additional repair contracts which one would not otherwise get but for the possession of such a dock, from which an adequate return was obtainable. If this is not possible, the only alternative is the raising of existing dock dues (which were based upon construction costs of most existing dry docks at about one-fifth of the present level) to rates bearing a more realistic relation to expenditure.

One would like to look to our civil engineering friends for a technique and plant, by drag-line or otherwise, which would reduce the present heavy costs of construction. There seems to be some scope for this, particularly in the high cost and time of excavation and disposal, which can amount to 15 per cent. of the total cost. On such conditions and considerations the necessary modernisation and up-to-date expansions of British facilities for the handling of large ship repairs depend to-day.

This point of impossibility of full-capacity occupation—the need to have these large dry docks when called upon—but the inability to fill them with ships of that size means that these large dry docks, of 1,000 ft. length and over, spend the most of their time uneconomically, used for one ship of a little over half the length of the dock, or sometimes two small ships docked simultaneously. That is not surprising when there are at the present time only some 40 merchant vessels afloat—world tonnage, not all British—over 80 ft. beam and over 650 ft. overall length. The largest dry docks therefore serve a limited class, but this number will be augmented shortly by about 200 large tankers.

The provision of an intermediate gate, with the idea that, by so doing, a long-term job can be taken on in the inner portion while using the outer part for routine short-term jobs, does not seem to work out in practical reality; and these intermediate gates seem rarely to be used in practice or to justify the extra expense of their provision. This economic question of maximum possible usage leads to an excursion into the design of ship-repairing premises from the users' point of view alone, not as a civil engineer, and gives rise to Fig. 3,* opposite.

It involves a re-orientation of the normal layout, square or obliquely off the fairway, into one with the dock parallel to it. Those who have experienced beam winds and gusts, heavy stream water on the beam in tidal rivers—particularly after the turn of the tide, due to a late arrival of the ship (or pilots and tugs), will agree that it is somewhat easier to handle ships into such a dry dock than the normal type. The real point, however, of the double-ended large dry dock design, with a variable position of one or more intermediate gates, is the large variations in occupancy and flexibility which is possible, and serves to overcome the full-employment-white-elephant problem previously referred to. It is a possible arrangement, with the outer wall constructed on reclaimed land as shown, or with certain site shapes, or, indeed, when the inner end is adjacent to and can be connected up with a wet basin, assuming, of course, the nature of the ground and water level are suitable.

Not the least important matter bearing on the pressure of dry-dock capacity to-day and the future of the ship-repairing industry in this country competing with Germany, Italy, the near Continental ports and Japan, is the time factor. Like port delays, time for repairs is increasingly important with larger and costlier units off earning time. There is a vital necessity for both sides of the British industry to realise that, with competition, even initial cost of repairs can be to some extent secondary in busy times to speed of turn-round, such as is accomplished by our foreign competitors working a three-shift system and every day of the week. Opposition to overtime and demarcation difficulties in this country are long overdue for consideration and amendment if the industry is to maintain its position in more difficult days.

* Fig. 3, as reproduced, is simplified from the Fig. 3 of the original paper, which also includes an elevation, cross-section and diagrams illustrating variation of usage.—ED. E.

PRODUCTION PRESS BRAKE.

A NEW model, the 96/36, shown in Fig. 1, has been added to the "Besco" Mark II range of production press brakes made by F. J. Edwards, Limited, 359-361, Euston-road, London, N.W.1. It has a 36-ton capacity and a bed 96 in. in length. A feature of this model is the 2-in. adjustment of the ram for setting, in place of a bed adjustment. It is claimed that this change provides a more positive tool location and removes the tendency of the tool to depart from its set position. The adjustment is made by a crank-handle connected with a worm and wheel which drives the screwed pitman link (Fig. 2). The ram is secured by locknuts.

The press is made of heavy rolled plate. The main drive is provided by a 4-h.p. 1,440-r.p.m. electric motor mounted at the rear; V-ropes link the motor to the main crankshaft through the reduction gearing and a multi-plate clutch. The clutch is operated by a treadle at the front of the machine. The automatic brake is operated by release of the clutch treadle and stops the ram movement at top dead centre. The gears are double helical to give quiet running and the pinion and flywheel shaft run in ball bearings. Guards are provided for all the moving parts. The ram is carried in long slides provided with an adjustment for taking up the wear. Lubrication of the press is by grease nipples. A grease gun is attached to the side of the machine for this purpose.

The lower tool-holder is detachable. It has dovetail slots at the front and back to enable clamps and gauges to be attached, and is machined on all faces. The press is equipped with a standard pair of forming dies for 90-deg. bends, with a $\frac{7}{8}$-in. V-opening in the die suitable for producing a bend in 14-s.w.g. sheet over the full length of the bed. Alternative dies are also available with $\frac{7}{8}$-in. openings for 60 in. by 12 s.w.g., and 1-in. openings for 48 in. by 10 s.w.g. The distance from the top beam to the bed, with stroke and ram adjustment completely raised, is $9\frac{1}{2}$ in. Depth of the gaps is 6 in. and the distance between the housings is 85 in. The machine runs at a maximum rate of 30 strokes per minute. It is 87 in. high, occupies a floor space of 117 in. by 55 in. and weighs approximately 64 cwt. The "Besco" models 48/36, 60/36 and 72/36, with beds of 48 in., 60 in. and 72 in., respectively, are now also being made in Mark II form with the new ram adjustment

NOTES ON NEW BOOKS.

Strength of Materials.

By ARTHUR MORLEY, O.B.E., D.Sc., Hon.M.I.Mech.E. Tenth edition. Longmans, Green and Company, 6-7, Clifford-street, London, W.1. [Price 25*s.*]

THIS excellent text-book, familiarly known as "Morley's *Materials*" by successive generations of students ever since it was first published in 1908, has reached the tenth edition and, altogether, 97,000 copies have been printed. It has now been republished with yet a further series of additions, particularly in relation to helical springs, electrical-resistance strain gauges and strain analysis, made by Dr. Morley himself. Its established place among previous text-books, when combined with its remarkably low price of 25*s.* for nearly 600 pages, must recommend it unfailingly to present-day students as well as to engineers who, although long past their student days, have not acquired a copy of "Morley" but yet have occasional need to refer to a book of this character. One small criticism—although it is appreciated that the very low price might have to be abandoned if the criticism was to be met—some of the illustrations, particularly the half-tones, look very old-fashioned among the newly-set type.

The Cathode-Ray Oscillograph in Industry.

By DR. W. WILSON, A.M.I.E.E. Fourth, revised, edition. Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 36*s.* net.]

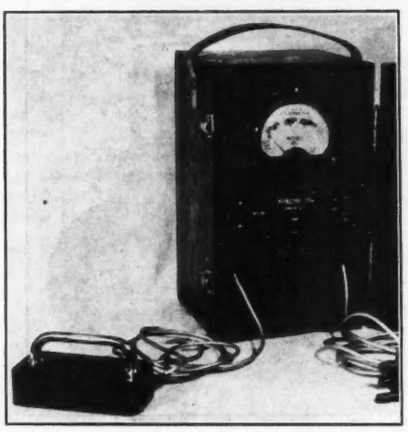
WHEN four editions of a technical book appear in ten years there can be no doubt about the increasing popularity of its subject or the exceptional ability of its author. The late Dr. Wilson combined, in fact, an authoritative knowledge of the theory and practical use of the cathode-ray oscillograph with a remarkable insight into the problems, no less than the possibilities, of its industrial applications. His talent for clear, concise exposition is already so well known to so many readers that this latest revision of his book, completed by Mr. G. L. G. Jeans after Dr. Wilson's death, evokes interest mainly in respect of its new subject matter, among which the results of recent work on fluorescent screens and radiolocation figure prominently. The most extensive addition concerns the post-war advances in the design and industrial applications of the electron microscope, but an appendix describing the development of metal tube oscillographs is an almost equally notable new feature. The present text is, consequently, about as nearly up-to-date as is possible in a rapidly enlarging field, and engineers and physicists will find it most instructive both as a general introduction and as a source of reference and inspiration in experimental research.

ELECTRICITY SUPPLY STATISTICS.—During March, 1953, 5,460 million kilowatt-hours were sold by the British Electricity Authority to the Area Boards, an increase of 8·3 per cent. over the output in the same month of last year. When corrected for the weather and the number of working days, the increase was 7·3 per cent., the weather having been slightly colder and the working days more than in the corresponding period of 1952. The amount of electricity sent out by the Area Boards during the same month was also 5,460 million kilowatt-hours (some supplies are received from sources other than the Central Authority), compared with 5,041 million kilowatt-hours in March, 1952, an increase of 8·3 per cent. Supplies to "mainly industrial" areas increased by 6·8 per cent. and to "mainly non-industrial" areas by 10·3 per cent.

ELECTRODES FOR ELECTRIC ARC WELDING.—Five new electrodes for electric arc welding have been introduced by Murex Welding Processes, Limited, Waltham Cross, Hertfordshire. Of these, "Speedex" is a mild-steel electrode, designed to facilitate high-speed manual arc welding under normal operating conditions and with normal penetration; "Deepex" a penetration electrode for producing butt welds in the downhand position in mild-steel plate up to ½ in. thick, without edge penetration; and "Ferex B," a low-hydrogen type of electrode for welding medium-alloy steels and mild steel. Of the other two, "Contex" has been designed primarily for welding downhand and overhead joints in mild and low-alloy high-tensile steels by "touch welding" and "Cinnifex" for welding nodular and other high-ductility types of cast iron.

DETERMINING THE POSITION OF REINFORCEMENT IN CONCRETE.

THE number of occasions on which it is desirable to determine the position of reinforcement embedded in concrete—if possible, without disturbing the concrete—are legion. On structural sites, it is frequently desirable to prove the position of reinforcement to ensure that it was correctly located in the first place or not moved when the concrete was being placed and consolidated; for maintenance work on old buildings, the exact position of the reinforcement is often a matter of doubt; in the factory producing precast concrete units, as well as in the laboratory, the same problem is likely to occur with considerable frequency. Working in conjunction with the Research and



Development Division of the Cement and Concrete Association, Wexham Springs, Berks., and the Cast Stone and Cast Concrete Products Industry, also at Wexham Springs, Kolectric Limited, 73, Uxbridge-road, London, W.5, have designed and are making instruments, to be called "Covermeters," that have been devised to overcome the difficulties of determining the position of the bars. The instrument can also be used to indicate, however, the exact location of the bars and their longitudinal axes. Designed for field, workshop as well as laboratory use, the instrument is simple to use, and can be operated by an unskilled workman.

The Covermeter, which indicates directly in inches the cover over the reinforcement, up to a maximum of 2 in., depends on the reluctance of a magnetic circuit; to all intents and purposes, all reinforcement is made of steel and its presence can be detected by the effect that it has upon the field of an electro-magnet. When in use, it is arranged so that the suspected reinforcing bar tends to close the air gap in a magnetic circuit incorporated in the search head of the instrument. The magnetic circuit comprises a U-shaped core of high permeability with a coil mounted on each leg. An alternating current is passed through one of these coils, so inducing a current in the other coil; this induced current, which is dependent upon the mutual inductance of the coils, is affected by the proximity of the steel reinforcement and the degree to which it closes the air gap. In the absence of any reinforcement, an appreciable standing current is induced in the second coil and this induced current is balanced by a suitable "backing-off" current. In practice, it is convenient to rectify both the induced and the backing-off current, and an increase in the former, due to closure of the air gap, causes a uni-directional passage of a current which activates a moving-coil meter housed in the main box of the Covermeter. The axis of the reinforcement is determined by orientating the search head until both coils lie directly above the bar, when a maximum effect will be registered on the meter. The instrument may be operated from either alternating-current mains or from a 6-volt accumulator; for transport and storage the search head and the leads fit into the compartment at the base of the instrument box.

BOOKS RECEIVED.

United States National Bureau of Standards. Circular No. 522. *Mass Spectroscopy in Physics Research.* Proceedings of the N.B.S. Semicentennial Symposium held on September 6, 7 and 8, 1951. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 1.75 dols.]

Treibstoffe für Verbrennungsmotoren. By DR. ING. FRANZ SPAUSTA. Second revised edition, in two volumes. Vol. I. *Flüssige Treibstoffe und ihre Herstellung.* Springer-Verlag, Mölkerbastei 5, Vienna, Austria. [Price 77*s.* 6*d.*]

Metallurgical Abstracts. General and Non-Ferrous. Vol. 19, 1951-52. Edited by N. B. VAUGHAN. The Institute of Metals, 4, Grosvenor-gardens, London, S.W.1.

Strength of Materials. By PROFESSOR JOHN W. BRENEMAN. Second edition. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 3 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 25*s.* 6*d.*].

Kinematics of Mechanisms. By PROFESSORS N. ROSENAUER and A. H. WILLIS. Associated General Publications Pty., Limited, 26, Hunter-street, Sydney, New South Wales, Australia. [Price 90*s.* (Australian).]

Les Diagrammes Enthalpie-Entropie. Applications à l'Air et aux Gaz de Combustion. By DR. P. CHAMBADAL. Dunod, 92, Rue Bonaparte, Paris (6e). [Price 940 francs.]

Pomps, Ventilateurs, Compresseurs, Centrifuges et Axiaux. By A. DE KOVÁTS and G. DESMUR. Dunod, 92, Rue Bonaparte, Paris (6e). [Price 3,800 francs.]

Leadership in the Factory. By JOHN MUNRO FRASER. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 3*s.*]

Timbers for Battery Separators. Bulletin No. 271. Commonwealth Scientific and Industrial Research Organisation, Melbourne, Australia.

The Steam Locomotive in America. Its Development in the Twentieth Century. By ALFRED W. BRUCE. W. W. Norton and Company, Incorporated, 101, Fifth-avenue, New York, 3, U.S.A. [Price 7.50 dols.]; and George Allen and Unwin, Limited, 40, Museum-street, London, W.C.1. [Price 45*s.*]

India. Central Board of Irrigation and Power. Publication No. 43. *Land Reclamation.* Vol. I. By M. L. MEHTA. Government of India Press, Simla.

Radio Engineering. By DR. E. K. SANDEMAN. Second revised edition. Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 55*s.* net.]

Statistical Tables and Problems. By PROFESSOR ALBERT E. WAUGH. Third edition. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 3 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 25*s.* 6*d.*]

An American in Europe. The Life of Benjamin Thompson, Count Rumford. By EGON LARSEN. Rider and Company, Hutchinson House, Stratford-place, London, W.1. [Price 15*s.*]

TRADE PUBLICATIONS.

Horizontally-Opposed Petrol Engines.—An instruction manual and spare parts list for the Coventry Victor type "N" (Mark 2) four-stroke horizontally-opposed twin-cylinder petrol-engine have been issued by Coventry Victor, Ltd., Cox-street, Coventry.

Infra-Red Projectors.—We have received from Metropolitan-Vickers Electrical Co., Ltd. a well-illustrated catalogue describing the equipment they manufacture for producing infra-red radiation and also the purposes for which it is being used.

Chain Travelling-Grate Stokers.—Babcock & Wilcox, Ltd., Farringdon-street, London, E.C.4, have sent us well-illustrated brochures dealing in detail with their Style 6 and Style 133 chain-grate stokers and giving similar information on their Style 28 travelling-grate stoker.

All-Insulated Industrial Wiring System.—British Insulated Callender's Cables, Ltd., Norfolk-street, London, W.C.2, have sent us a brochure dealing fully with their all-insulated industrial wiring system. This has been specially designed to be completely watertight and virtually proof against fumes and corrosion. It is intended for use in installations where the voltage to earth does not exceed 250 volts.

Electricity in the Spinning Industry.—A reprint of Mr. S. McCracken's address on "The Application of Electricity to the Spinning Industry of Northern Ireland," which was delivered to the Northern Ireland Centre of the Institution of Electrical Engineers on October 9, 1951, has been issued by Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17.

Short-Break Alternating-Current Switches.—Simplex Electric Co. Ltd., Broadwell, Oldbury, Birmingham, have sent us particulars of a new 5-amp. switch which operates on the slow short break principle and is being marketed under the name of "Miniac."